Tel Aviv University

The Lester and Sally Entin Faculty of Humanities

The Linguistics department

Prosodic Deficit in the Perception of Focus: Evidence from Hebrew Speaking Individuals with Asperger Syndrome

M.A thesis submitted by

Hadass Zaidenberg

Under the supervision of

Prof. Outi Bat-El and **Prof. Naama Friedmann**

November, 2015

Table of content

Abstract

Individuals with autism spectrum disorders and Asperger syndrome are often described as having pronounced abnormalities associated with the prosody of speech. This was already reported as a marked feature of impaired communication in Kanner's (1943) early description of autism.

Although reports are inconsistent with regard to the description of disrupted prosody in autism and its distribution, it is commonly established that expressive prosodic deficits are one of the major inhibiting factors obstructing successful social communication and integration. However, not enough is known about the nature of *receptive prosodic deficiencies* in autism and about the interface of such impairments with expressive aspects of prosody and with other cognitive and lingual abilities such as pragmatic competence and Theory of Mind.

The present study focuses on receptive prosody, aiming to assess whether individuals with Asperger syndrome perceive and comprehend prosodic information differently than typically developed individuals. Furthermore, the study compares the Asperger groups' performance in processing various prosodic patterns of several domains of speech – grammatical prosody, pragmatic prosody and affective prosody (Crystal 1986, Merewether and Alpert 1990, Roach 2000). Evidence from research of hemispheric dominance and of unilateral brain damaged patients (Heilman et al. 1984, Behrens 1985, Emmorey 1987, Luks et al. 1998,) as well as from studies of impaired prosody in various disorders (Murphy and Cutting 1990, Wells and Peppé 2003, Shriberg et al. 2001, Paul et al. 2005, Fosnot and Jun 1999) suggests that these functions of prosody could be independently affected to some extent. Earlier research on prosody in autistic spectrum disorders, though somewhat inconclusive, laid the ground to assume that prosodic deficits will emerge in the aspects of prosody associated with emotive and pragmatic functions, whereas grammatical functions will remain mostly intact (Kujala et al. 2005, Chevalier et al. 2009, Shriberg et al. 2001, Paul et al. 2005).

A group of 10 participants with Asperger syndrome (mean age 30;4, SD=4.2) and a control group of 30 typically developed individuals (mean age 25;1, SD=4.0) participated in the present study. The experiment consisted of a battery of 16 prosodic tasks designed to assess the participants' ability to discriminate and comprehend prosodic patterns of various prosodic functions. In order to further appraise linguistic

and cognitive abilities and to examine possible correlations, the participants were also measured for Theory of Mind abilities, working memory capacity, syntactic and lexical competence, reading ability and pragmatic skills.

Results indicate substantial deficit in the proso-pragmatic aspect of *focus perception*. This difficulty was shared by most of the participants in the Asperger test-group (8 out of 10 participants). Difficulties in grammatical and emotive aspects of prosody were inconsistent and featured in only four of the Asperger test-group's participants. These difficulties were highly correlated with verbal ability (vIQ), working memory and formal language skills.

The findings of this study are discussed in light of the unique properties of *focus constructions* and *focus interpretation mechanisms*, suggesting that the Asperger test-group's shared difficulty might be the outcome of a selective deficit in focus-related operations. The obtained results are also discussed with regard to the conventional categorization of prosodic functions and the ability to define the scope of prosodic impairments in terms of these functions.

Acknowledgements

This work is not an endpoint. It is an intermediate pause in the research journey that I began several years ago and that I intend to pursue and extend in the years to come. It could not have happened without the inspiration and guidance of my two thesis advisors, Outi Bat-El and Naama Friedmann, who have been my greatest teachers, critics and supporters all along. My academic path has been a mixture of interests. I have had the opportunity to engage in various enriching experiences and delve into different, fascinating fields. It has definitely made the road longer, but I believe that it has also made it wider. My advisors fulfilled a dual role upon guiding me through this process. They gave me the liberty to wander far, while helping me focus and fine-tune my efforts. Outi and Naama, I cannot thank you enough for your support and devotion, for sharing your insightful opinions and thoughts with me, for being so open-minded and for your endless patience. Your influence on my academic experience is immeasurable. That said, it should be clarified that any remaining errors or mistakes in this thesis are my own.

I would like to express my sincere gratitude to a few other great minds who contributed substantially to my work.

First, I owe many thanks to Roni Katzir. Thank you for insightful conversations and for your enlightening ideas, for providing me with invaluable reading materials and for helping me ask the right questions and refine my thoughts. Your contribution to my work is immense.

I was fortunate enough to have this work read by Mira Ariel. I thank you, Mira, for all the important references, for your insightful remarks and helpful advice which gave me innumerous ideas for future work.

I owe many thanks to Noga Balaban. Thank you for allowing me to use your wonderful aTOMic battery, for hours of interesting and encouraging conversations, and for being a good listener and an incredible friend.

I would also like to thank Nirit Kadmon for her enriching course ‘Topics in the Interface of Prosody and Pragmatics’, for interesting and helpful meetings and for her questions and remarks at the interdisciplinary colloquium.

I am also grateful to Aya Meltzer-Asher and Julie Fadlon for being so patient in helping me with statistical issues, and to Lea Marcu who helped me in conducting the VIQ tests.

Finally, I would like to thank Ruth Berman, Galit Adam and Evan Cohen. I was fortunate to have the opportunity to work for them in various projects and I am very thankful for their support and interest in my work and progress.

I was extremely lucky to study and work with some brilliant, talented and caring friends, who taught me many things and helped me in many ways. Aviad Albert, Noa Karni, Ezer Rasin, Chen Edelsburg, Ran Abramson, Chen Gafni, and Gal Belzitsman – you inspire me. Your assistance and support are immeasurable and I could not have asked for better companions for this journey.
I am also grateful to my fellow TAs and colleagues, with whom I had the pleasure to work along the years – Daniel Asherov, Si Berrebi, Noa Brandel, Yael Firer, Lyle Lustigman, Avi Mizrachi, Lior Ordentlich and Hadas Yeverechyahu, your dedication and devotion are exemplary.

I am thankful to the members of the Phonology-Circle (IPhonC), the participants of the Interdisciplinary Colloquium at the Linguistic department and the members of the Language and Brain Lab, who heard my talks in different stages of this research and enriched me with their questions and thoughts. I would also like to express my deepest gratitude to the faculty and staff members of the Adi Lautman Interdisciplinary Program for Outstanding Students and of the Linguistic department, I have learned from all of you.

I owe many thanks to Ruti Zussman and Tal Oded, the Linguistic department's administrators, for their magical powers in handling any bureaucratic issue and removing every structural barrier with a smile and a hug, and for always having the best intentions.

I would like to express my sincere gratitude to all those who generously sponsored and supported me and my research – the Lautman family, the Posis scholarship, the Friedman scholarship, the Goldman scholarship and the Dean of the faculty of Humanities scholarship.

And of course, I am very grateful to all the participants who took part in this study and to their committed caregivers. I thank you all for your willingness and your collaboration.

Finally, I would like to dedicate this work to my amazing family who is always my greatest inspiration. To my sweet grandma, Ruti, who was always charged with infinite energy and handled everything with a genuine smile, and to my incredible grandma, Menucha who at the age of 101 still shows me how important it is to learn something new every day. To my mom, Evelyn, who speaks every language, and my dad, Rami, who understands every word. You are the best example that I know of for real curiosity. To my two brothers, Yoav and Tomer, my best friends, with whom I share, and always have shared, an inner-voice and one mother-tongue. And to my husband, Oded, my love, who is with me from the very beginning to the very end of every thing I do and who is always my first and final word.

List of Acronyms

ADD	Attention Deficit Disorder
ADHD	Attention Deficit Hyperactivity Disorder
ADI-R	the Autism Diagnostic Interview – Revised
ADOS	the Autism Diagnostic Observation Schedule
APA	American Psychiatric Association
AS	Asperger Syndrome
ASD	Autism Spectrum Disorders
DS	Deep Structure
DSM	The Diagnostic and Statistical Manual of Mental Disorders
ERP	Event-Related Potential
F	Focus
HFA	High Functioning Autism
ICD	International Classification of Diseases
IP	Inflectional Phrase
LF	Logical Form
MMN	Mismatch Negativity
NP	Noun Phrase
OCD	Obsessive-Compulsive Disorder
PDD	Pervasive Developmental Disorders
PDD-NOS	Pervasive Developmental Disorders Not Otherwise Specified
PF	Phonological Form
PP	Prepositional Phrase
Q-S	Question - Statement
RT	Response/Reaction time
SI	Scalar Implicatures
SLI	Specific Language Impairment
SS	Surface Structure
ToM	Theory of Mind
vIQ	Verbal IQ
VP	Verb Phrase
WAIS	the Wechsler Adult Intelligence Scale

1. Introduction

Asperger syndrome (henceforth AS) is considered to be an autistic spectrum disorder, hence, it is a part of a group of neuropsychiatric developmental syndromes that is characterized by marked impairments in social interaction and social communicative skills as well as by restricted and stereotyped patterns of behavior, interests and activities (APA 2000, World Health Organization 1993 - ICD-10, Wing and Gould 1979, Attwood 1998, 2006, Szatmari 2000, Klin and Volkmar 2000, Volkmar and Klin et al. 2000, Wing 1997).

Unlike other Autism Spectrum Disorders (ASD), traditional approaches do not couple AS with atypical language acquisition or impaired cognitive development. Individuals with AS are described in the diagnostic literature as having normal intelligence and verbal ability (World Health Organization 1993 - ICD-10, APA 2000). Nevertheless, whereas formal linguistic skills such as syntax or semantics are considered to be intact (Ghaziuddin et al. 2000), researches indicate that individuals with AS may experience some communicative problems that are associated with speech.

Prosodic irregularities were reported to be a prominent feature of communication deficits in autism and AS, in both Kanner’s and Aperger's early descriptions of the autistic phenomenon (Kanner 1943, Asperger 1944). Different researches indicate that the productions of AS individuals are atypical in various aspects of prosody such as pitch range (monotonous speech or inappropriate and exaggerated tone of voice), pauses, length of speech sounds, stress and rhythm as well as in the correlation of prosody with emotional content (Fay and Schuler 1980, Hubbard and Trauner, 2007, Kujala et al. 2005, Shriberg et al. 2001, Rutherford et al. 2002, McCann and Peppé 2003, Peppé et al. 2006, Ghaziuddin and Gerstein 1996).

Reports are inconclusive and somewhat contradictory in describing the features of prosodic deficiencies in AS and in autism in general, and in defining the dispersion of prosodic impairments in the autistic population. In Simmons and Baltaxe 1975, four out of seven autistic participants demonstrated prosodic differences. More recent studies such as Shriberg et al. (2001) and Paul et al. (2005) support these ratios and indicate that abnormal prosody characterized approximately 50% of the autistic individuals that participated in their studies. Regardless of the deficit's rates, these studies emphasize that atypical prosody production forms major impediment that

obstructs successful social communication and social integration. In addition, unlike other linguistic abilities that tend to improve and evolve throughout the years, prosodic deficits seem to persist and show little change over time (Rutter and Lockyer 1967, Kanner 1971, Paul et al. 2005, Shriberg et al. 2001).

The prosody of speech is closely linked to several cognitive and pragmatic difficulties that are assumed to characterize the autistic population. Various studies of AS communicative skills indicate difficulties in pragmatic aspects of speech such as initiating and orienting discourse, and adjusting the form of discourse to the listener and to the state or situation. It was suggested that many of the AS participants experience difficulties in inferring implicit meanings of non-literal language, such as metaphors, figure of speech, similes, indirect requests, humor or irony due to the need to rely on social context and non-literal cues as the basis for understanding these ambiguous and multifaceted utterances (Tager-Flusberg 1999, Grandin 1992, Gillberg 2002, Volkmar and Klin et al. 2000). In spoken language, these cues and contexts are formed in many cases by the use of prosodic features, hence the ability to comprehend and process the pragmatic information conveyed in discourse largely depends on prosodic competence.

Furthermore, as in other autistic spectrum disorders, many AS individuals are commonly characterized by impaired Theory of Mind (ToM) skills, i.e. a deficit in the ability to relate mental states to behavior in different social contexts (Baron-Cohen et al. 1985, Baron-Cohen 1989). This cognitive ability, which allows a person to theorize the mind of the other and understand that others may hold knowledge, intentions and beliefs that are different from his/hers, is a basic and crucial condition for constructing communication. Mental and emotional states are often conveyed by non-linguistic features such as body gestures and facial expressions as well as by linguistic ones such as tone of voice, intensity and rhythm; all related to the prosody of speech. Therefore, a deficit in receptive prosody, or a lack of the understanding that prosody may be used to convey thoughts, emotions and intentions, could influence one's ability to identify and respond to mental and emotional states of others.

Prosody, as a suprasegmental quality of speech, affects and modulates the purport and function of different linguistic units in ways that may not be encoded by syntactic structure or lexical meaning. These properties of prosody fulfill a variety of functions in semantic, syntactic and pragmatic aspects of speech and it is an essential

tool in constructing multilayered discourse (Bolinger 1955, Ladd 1996, Pierrehumbert, and Hirschberg 1990).

The main objective of this study is to evaluate and map the abilities of AS individuals in perceiving prosody. This objective stems from the observation that even high-functioning individuals with normal verbal intelligence and good language skills tend to demonstrate some communicative problems that associate with speech. This work aims; therefore, to study the range and features of the prosodic deficit, to investigate its potential sources and to examine the possible effect of the interface between impaired prosodic reception and other linguistic and cognitive abilities.

1.1. Asperger syndrome

Asperger syndrome is named after the Austrian pediatrician Hans Asperger who, in 1944, almost simultaneously with the psychiatrist Kanner in the United States (Kanner 1943), described children in his clinic as lacking social communicative skills. He reported that his patients demonstrate limited empathy towards their peers, restrictive and isolated interests and deficiency of nonverbal communication as well as stereotypic behavior. He was the first to report oddities in non-verbal gestures such as body language and eye contact as well as abnormalities in tone of voice and prosody (for an English translation of Aspergers' work, see Frith 1991). Asperger's studies were published in German and remained mostly unnoticed until the early 80s when Lorna Wing's highly influential review and 34 case reports of AS patients were published (Wing 1981).

Asperger syndrome is an autistic spectrum disorder. The definition of AS, both in clinical practice and in research studies has been controversial throughout the years and the validity of this disorder as defined by the DSM-IV (The Diagnostic and Statistical Manual of Mental Disorders) in 1994, was in question, since there was no agreement that Asperger's disorder was indeed separate and distinct from high-functioning autism (Mayes and Calhoun 2001, Attwood 1998, 2006, Eisenmajer et al. 1996, Manjiviona and Prior 1995, Schopler 1998, Wing 1998). With the recent release of the DSM-5 (2013), Asperger's syndrome was excluded as a distinct disorder and it was clinically established that autism spectrum disorder is a continuum characterized by symptoms that differ only in degree and severity.[1]

[1] Based on the DSM-IV (1994) and DSM-IV-TR (revised version, 2000), patients could be diagnosed with four different pervasive developmental disorders (PDD) – Autism disorder, Asperger syndrome,

Within the group of autism spectrum disorders, approximately 20% of individuals display normal intellectual abilities (APA 2000, Klin and Volkmar 1997). These individuals, who were traditionally diagnosed as high-functioning autistics or Aspergers, demonstrate large spoken vocabularies and apparently intact formal language skills, whereas their deficits are claimed to be in the areas of pragmatics and social communication (Tager-Flusberg 1995).

The underlying neurological source of the autistic disorder is still not fully specified, although due to high heritability (an average concordance for identical twins of 64% vs. 9% for fraternal twins; Smalley et al. 1995) it is claimed that this is a genetically determined disorder (Freitag 2007, Freitag et al. 2010), namely that genetic factors play a major role in the formation of this syndrome. Males are more prone to be diagnosed with Asperger syndrome than females, with an estimated ratio ranging between 6:1 to 4;1 (Mattila et al. 2007, based on the Gillberg and Gillberg criteria Gillberg 1991).

Associated medical disorders are common among individuals with Asperger syndrome and autism spectrum disorders. Attested comorbidity is known with Attention Deficit Disorder (ADD), Attention Deficit Hyperactivity Disorder (ADHD), Depression, Anxiety, Obsessive-Compulsive Disorder (OCD) and Schizophrenia being the most prevalent (see Gillberg and Billstedt 2000 for a review of comorbidity in individuals with AS and ASD). Regardless of which individual neurological or genetic system represents the origin of deficit, typical patterns of developmental processes can be recognized and provide the basis for diagnosis (Lord et al. 1994).

Reports of AS prevalence in the population are diverse due to differences regarding several diagnostic criteria. Fombonne (2007) suggest that the incidence of AS might be around 0.25/1,000 births, whereas the prevalence of all autism spectrum disorders in general, is estimated at much higher rates. Mattila et al. (2007), conversely, report an estimated rate of around 2.5/1000 AS incidences.

For many years, the general population prevalence for autism was considered

---

Childhood disintegrative disorder or PDD-NOS – pervasive developmental disorder not otherwise specified. In the new DSM edition (DSM-5, 2013), these four distinct disorders are considered as one spectrum disorder under the umbrella of ASD – Autism spectrum disorder. Patients may differ in severity of symptoms but it is assumed that approximately 90% of those diagnosed with one of the four pervasive developmental disorders (PDD) from DSM-IV should still meet the criteria for ASD in DSM-5 or another, more accurate DSM-5 diagnosis (Huerta et al., 2012).
An explanation of the revision of ASD clinical definition is available at the DSM-5 website: http://www.dsm5.org/Documents/Autism%20Spectrum%20Disorder%20Fact%20Sheet.pdf

steady at around 0.4/1000 births. However, in 1998 the Brick Township, New Jersey reported a prevalence rate of 4/1000 for classic autism and 6.7/1000 for all PDDs. Most recent reports of the USA Center for Disease Control and Prevention (2012) indicate another sharp rise to a prevalence of 1 autism case for every 88 births (a rate of 11.3/1000). Similar trend was reported in 2005 by Chakrabarti and Fombonne. Their report of British children showed a prevalence rate of 6.2/1000 for all pervasive developmental disorders (PDDs) in which the majority of cases (71.1%) was found at the mild end of the autistic spectrum (i.e. high-functioning autism, Asperger syndrome and PDD-NOS).

According to a recent report of the state of Israel's Ministry of Social Services (2013), current available data are not sufficient to determine the exact rate of newly cases of autism out of annual births. However, it was indicated that the number of autistic cases that are reported to governmental services consistently increase every year. Most recent figures, that are considered underestimation, indicate a rate of approximately 5.3:1000 births.

Epidemiologic analyses indicate that recent high rates of autism may be attributed, at least to some extent, to the broadening of diagnostic criteria, improvement of diagnostic tools as well as to increased awareness to autistic symptoms of both the public and clinicians (Shattuck 2006, Taylor 2006). And yet, the substantial escalation in the prevalence of individuals diagnosed with autism reflects the expansion of the autistic phenomenon and reinforce the need of a body of research that aim to map and characterize different aspects of the autistic disorder.

1.2. Prosodic impairments in Autism and Asperger syndrome

This section presents some of the findings regarding prosody in autism. Much of the literature regarding the autistics' prosodic abilities has focused on prosody production and specifically on prosody’s usage in conveying affect and emotion. The literature regarding expressive prosody generally agrees that the ability to use pragmatic and affective prosody in high functioning autism (HFA) and Asperger syndrome is more affected than grammatical prosody competence. The literature regarding receptive prosody is, however, less conclusive.

The notion of *prosody* and prosody's various *functions* are introduced in sections 1.2.1-1.2.2. Sections 1.2.3 and 1.2.4 address some of the literature regarding expressive and receptive prosody amongst the autistic population and section 1.2.5

refers to Theory of Mind hypothesis and the relation of prosody and Theory of Mind deficiency.

1.2.1. Prosody

Prosody is the melodic and rhythmic dimention of speech featured by loudness, pitch and duration, as phonetic parameters (Lehiste 1970, Cruttenden 1997). These components comprise a complex vocal signal that is precieved as 'the melody of speech'. Prosody is a suprasegmental quality that applies to phonological units larger than a single segment and can play a role in different phonological domains such as syllable, word, phrase and utterance (Selkirk 1986, Ladd 1996, Cutler et al. 1997). Prosody modifies the function and meaning of these linguistic units in ways that are not necessarily dependent on syntactic structure or lexical-semantic relations and it can directly affect the speed and eficiency of language processing (Birch and Clifton 1995). These properties of prosody enable it to serve various aspects of speech - semantic, syntactic and pragmatic aspects, and facilitate the construction of complex and multilayered discourse.

Despite the complexity of the prosodic signal, it is naturally perceived and productively used by children from a very early stage of acquisition. Many of the phenomena that characterize children's early speech, such as syllable omissions and the use of epenthetic filler syllables, could be attributed to prosodic requirements (Gerken and McGregor, 1998, Adam and Bat-el 2008, 2009, Albert and Zaidenberg 2012). According to the ‘prosodic bootstrapping hypothesis (Gleitman and Wanner 1982, Peters 1983, Hirsh-Pasek et al. 1987, Gleitman et al. 1988, Morgan and Demuth 1996 and Christophe et al. 1997), prosodic information (and stress in particular) is one of the major implements that enables infants to acquire a lexicon, to distinguish content words from function words, to identify the boundaries of syntactic constituents and to parse and divide the continuous stream of speech to fragments. This hypothesis suggests that young infants rely on prosody as a 'bootstrap' into the linguistic system and use prosodic cues in speech to gain valuable knowledge about the syntactic organization. Consequently, according to this view the acquisition of various linguistic structures depends, to some extent, on sensitivity to prosodic patterns.

These unique features of prosody make it an essential tool for language acquisition and communication (Bolinger 1955, Ladd 1996, Pierrehumbert and Hirschberg 1990, Wilson and Wharton 2006).

1.2.2. Prosodic Functions

There are several accounts for the domains of speech in which prosody functions (Crystal 1986, Merewether and Alpert 1990, Kent and Read 1992, Panagos and Prelock 1997, Shriberg et al. 2001, McCann and Peppé 2003, among others). These domains can be generally categorized as - grammatical uses of prosody, pragmatic uses of prosody and affective uses prosody.

1.2.2.1. ***Grammatical Prosody*** comprises of suprasegmental features that are used to encode information relevant for syntax (Warren 1996) such as word lexical stress, sentence phrasing and segmentation, and denotation of sentence class (e.g. interrogative vs. declarative). These prosodic cues are generally inherent obligatory features of the utterance's surface structure (Gerken and McGregor 1998).

As exemplified in (1) below, the different stress patterns in Hebrew words; penultimate vs. final stress, may directly affect the meaning and function of the lexical entries. Contrast in lexical stress can denote different lexical and semantic categories (1a), and different meaning within the same category (1b).

(1) Contrastive lexical stress

a. Different lexical category - different meaning

Noun		Verb	
óxel[2]	*'food'*	oxél	*'eat present, ms. sg.'*
kóʃer	*'fitness'*	koʃér	*'tie present, ms. sg.'*
Náal	*'shoe'*	naál	*'locked past, 3p. ms. sg.'*

[2] Lexical stress is indicated in this paper by a diacritical marker placed above the nucleus (vowel) of the stressed syllable

b. Same lexical category - different meaning

Noun		**Noun**	
bóker	*'morning'*	bokér	*'cowboy'*
Bíra	*'beer'*	birá	*'capital city'*

Verb		**Verb**	
Áfa	*'flies present, fem. sg.'*	afá	*'baked past, ms. sg.'*
Cáfa	*'floats present, fem.sg.'*	cafá	*'watched past, ms. sg.'*

Beyond the word level, prosody is used to mark phrase boundaries in speech (Amir et al. 2004). Prosodic phrasing is essential for segmentation of utterances and for disambiguation of syntactic structures. Intonation contours signal the end of a phonological unit and the relation between phonological units within an utterance, hence prosody has a strong connection with the internal structure of the utterance (Selkirk 1986, Selkirk 1995, Truckenbrodt 1999, Pierrehumbert and Hirschberg 1990, Bakenecker et al. 1994).

The following example from English (2) is ambiguous with regard to the presence or absence of grammatical boundaries within the sentence. The ambiguity is resolved in writing by the use of punctuation, dictating differences in terms of structure and meaning between the two sentences (2a) and (2b).

(2) Ambiguity of syntactic structure

Ambiguous sentence: I ate fruit salad and some yogurt

Two interpretations: a. I ate **fruit-salad**, and some yogurt

b. I ate **fruit, salad**, and some yogurt

In speech, it is the intonation pattern that encodes the syntactic structure of these phrases and their meaning through sequencing of pitch changes and pauses. Prosodic phrasing has also been proposed to aid comprehension by arranging linguistic units to be maintainable in short term memory, prior to high processing procedures (Frazier et al. 2006).

Another aspect of language's sound system that is relevant to signal syntactic information and determine the utterance's class is the pitch contour of utterance's boundary, which denotes whether a sentence is a question (characterized by final

rising contour) or a statement (signaled be a falling contour). For example, the following sentences in (3) contain identical sequence of words and could be interpreted as a question or a statement based on the boundary tone at the end of the phrase, whether it is falling (3a) or rising (3b):

(3) Pitch contour denotes utterance's class

a. Ruth is here**.** ↘

b. Ruth is here**?** ↗

The prosodic information that modulates grammatical structure and directly affects meaning is a crucial aspect of any spoken language.

1.2.2.2. ***Pragmatic prosody*** carries communicative information beyond that encoded by syntactic structure and semantics of the utterance. Pragmatic aspects of prosody could be communicated by different cues that convey the speaker's intended meaning. Emphasizing different constituents in an utterance can reflect hierarchy of information in terms of importance or novelty (new vs. given) and subtle intonation changes could imply for turn taking and define the course of the dialogue. Other paralinguistic inferences such as irony, or humor in general, could also be expressed by prosodic changes for pragmatic purposes (Ariel 2008, Giora 2003).

Central information in an utterance, as in the examples (4-6) below, could be indicated prosodically by *focus*, an accent placement that encodes the relative prominence of a constituent, within the utterance. It is assumed that the focus of a sentence contains its' informative segments, those which cannot be inferred from the discourse.[3]

(4) a. Who patted the dog?

b. [RUTH]$_F$[4] patted the dog.

The expression *RUTH* in (4b) forms the answer to the question in (4a). It is new information that is not given by the context of the question in (4a), i.e. this expression

[3] I do not commit at this point to any specific approach to focus assignment or interpretation, see 10.1 for an overview of relevant focus theories.

[4] Henceforth pith accent will be noted by uppercase letters and focused phrases will be indicated by brackets and marked with an *F* subscript.

could not be extracted by inference or by entailment from the immediate context and therefore it is emphasized by an accent.

In the case of (5b) below, the expression in focus is emphasized to reflect a contradiction to the utterance in (5a).

(5) a. Ruth petted the dog.

b. No, [GREG]$_F$ petted the dog.

The accent pattern of the utterance in (5b) indicates as given that *'someone petted the dog'* and thus gives rise to the interpretation that the contradiction should not be taken as applying to the entire proposition in (5a) rather it should apply narrowly to *Ruth*.

In the case of the utterance in (6), even in the absence of previous context, the association of the negation operator with the focused expression strongly implicates that somebody **did** pet the dog, but it was not *RUTH* who performed that act.

(6) It is not the case that [RUTH]$_F$ petted the dog.

The above examples of prosodic prominence could not be conveyed solely by the formal structure or meaning of an utterance. These examples emphasize the common view according to which language pragmatics leans intensively on prosodic cues.

1.2.2.3. ***Affective prosody*** holds affective and emotional information and reflects the speaker's mental state. It conveys speaker's mood, feeling and attitude. The affective function is considered a more global aspect of prosody since it carries non-literal meanings which are mostly paralinguistic and originate outside of language. The contribution of this function to the discourse is in introducing cognitive and emotional information that could not be extracted from grammatical or lexical meanings, neither from formal semantic or pragmatic inferences (Bolinger 1989, Peppé and McCann 2003, Paul et al. 2005).

For example, the utterance in (7) below would be considered by most readers as a neutral sentence in terms of emotion.

(7) I got a B on my math test

This sentence however could be interpreted as a positive or as a negative statement as an outcome of the pitch height, the pitch range and the rate in which it was uttered. An utterance that conveys positive affect will be generally featured with higher pitch,

wider pitch range and an accelerated rate in comparison with an utterance that conveys negative affect. These emotive properties of prosody are paralinguistic in nature and they enable speakers to produce a rich and diverse range of meanings and to construct multilayered discourse through expressive language.

1.2.3. Expressive prosody in autism – prosody production

For individuals with ASD the nonverbal use of prosody in communication might pose a challenge. Irregularities in prosody production have been observed in both high- and low-functioning individuals diagnosed with autism, and abnormal expressive prosody was identified as an autistic characteristic since its earliest descriptions (Kanner 1943, and Asperger 1944). Throughout the years, various studies indicate production abnormalities in a variety of aspects.

McCaleb and Prizant (1985) investigated the pragmatic use of ***contrastive focus*** in the verbal performance of four autistic children (age 4;8-14;10). The participants in this study equally accented *old* and *new* information in spontaneous speech, a pattern that resulted in incorrect assignment of *focus*. Inappropriate placement of *contrastive focus* was, in fact, detected in the vast majority of studies that investigated *focus* production in the autistic population; e.g. Baltaxe and Simmons (1985), Fosnot and Jun (1999), Shriberg et al. (2001) Paul et al. (2005) and Peppé et al. (2007) among others). Additionally, while the AS and HFA groups in Fine et al.'s study (1991) did not differ from control in focus placement in *neutral* utterances (i.e. non-contrastive contexts), several other studies suggest that even in *neutral* utterances, autistic individuals are more likely to produce inappropriate accent pattern (Baltaxe and Gutherie 1987 and Peppé et al. 2007). These studies indicate that in *neutral* utterances autistic individuals are more likely to accent the first word in the sentence though the appropriate default accent should be assigned to the last word.

In contrast with the findings regarding sentential *focus*, most studies that investigated the production of word level ***lexical-stress*** found it to be appropriately assigned by autistic individuals (e.g. Shriberg et al. 2001, Grossmann et al. 2010).[5]

[5] According to Grossman et al. (2010) the autistic participants were able to accurately differentiate stress patterns in their production; however, participants' utterances were abnormally long. Atypically long word duration was also found in Baltaxe (1981), according to which HFA's word durations in sentences were similar to word durations in isolation, and in Fosnot and Jun (1999), indicating significantly longer duration in both interrogatives and declaratives. Hence, the irregular word duration

Paul et al. (2005) is the only study I know of that indicates a significant difference between autistics and controls in lexical tress production.[6]

With regard to ***phrasing***, Thurber and Tager-Flusberg (1993) investigated the use of grammatical pauses (phrase boundaries) and pragmatic pauses (within phrases) in a narrative elicitation task. The results indicate that a group of ten autistic participants (mean age=12;1 SD=2;7) was able to use grammatical pauses correctly to signal phrase boundaries, whereas their use of pragmatic pauses was less frequent in comparison with ten children with mild mental retardation and ten typically developed children. The results of this study are compatible with those of Fine et al. (1991) according to which autistic individuals use boundary tones adequately to signal the end of intonation phrases. In contrast with these studies, the autistic group in Paul et al.'s (2005) study (HFA, AS and PDD-NOS, N=27, age 14-21) was found to be no different from control in prosody production tasks of both grammatical and pragmatic/affective phrasing. However, Paul et al.'s *pragmatic/affective phrasing task* is somewhat controversial since the main correlate of *phrasing* in this task was *rate of speech* (the participants were asked to read target-sentences in an *exited* vs. *calm* manner), whereas in the *grammatical phrasing task* phrasing was manifested by a complex pattern of pauses, syllable duration and pitch contour. Hence, the extent to which the *pragmatic/affective task* in Paul et al.'s study reflects parsing sequences of words into phrases is unclear.

Results of production studies are inconsistent when it comes to production of ***interrogatives*** and ***declaratives***. Paccia and Curcio (1982) report that the five autistic children in their study (age 6;11-16;10) used falling pitch contour in the production of questions in a repetition task. The authors argued, however, that this prosodic modification served a semantic function of affirming the experimenter's question. The same falling pitch pattern in the production of questions was found in both reading and repetition tasks in Fosnot and Jun (1999). However, it should be noted that though

---

in Grossman's study might be an independent characteristic of the autistic participants that is not directly associated with the production of lexical stress.

[6] It should be noted that the lexical-stress production task in Paul et al. (2005) has several methodological weaknesses that might affect task's reliability and therefore should be taken into consideration. The participants in this task were asked to silently read a sentence and then read aloud one ambiguous target-word that was underlined (e.g the word *conduct* in the sentence: *'Your <u>conduct</u> in school should be better'* (Paul et al. 2005, p. 216)). Beside the fact that the task involves reading skills, there was no confirmation that participants did in fact read the entire sentence before uttering the target word. Obviously, not reading the context sentence can affect the participants' ability to utter the ambiguous word correctly in terms of word-stress.

the four autistic children in Fosnot and Jun's study (age 7-14) were defined as sight-word[7] readers, their familiarity and awareness to the function of the question mark *'?'* was not asserted (McCann and Peppé 2003). The above results are contradicted by Paul et al. (2005) who did not detect differences between autistics and controls in a production task of questions and statements.

In terms of ***affect***, according to Lord et al. (1996), parents of autistic children report pronounced difficulties in identifying and interpreting emotions conveyed in their children's speech in comparison to parents of children with mild mental retardation and parents of typically developed children. Further support for this difficulty is found in Peppé et al.'s (2007) affect production task, in which 31 children with HFA (age 6;1-13;6) were asked to express *liking* or *disliking* of food items. Peppé et al. indicate that the autistic group's productions in this task were misjudged, or judged as ambiguous by the tester, significantly more often than the control's productions. In contrast, in an affect production task Paul et al. (2005) did not find differences between the performance of the autistic and the control groups in producing utterances in an *exited* or in a *calm* manner.

Though some of the findings regarding expressive prosody in autism, as reflected in the above studies, are contradictory to a certain degree, it is generally assumed that autistic individual's ability to convey pragmatic and emotive information through prosody is more disrupted than grammatical aspects of prosody which are relatively spared.

These various observations regarding the autistics irregular productions led to the inclusion of prosodic abnormalities (in intonation, volume, rhythm and rate) as symptoms in the conventional diagnostic protocols of the autistic disorder - the Autism Diagnostic Interview - Revised (ADI-R; Le Couteur et al. 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 1999).

1.2.4. Receptive prosody in autism - prosody perception

In comparison to prosody production, studies of prosody perception are rather scarce in the literature of prosody in autism, with the exception of those investigating the perception of affect as conveyed in speech. This trend has begun to change in the past decade, when a number of research groups have focused their efforts on evaluating

[7] *Sight words* are high frequency, repeatedly used words that children are encouraged to memorize as a whole in order to recognize these words on sight.

different aspects of prosody perception and investigating the role of prosody in language comprehension amongst autistic individuals. However, the findings of these important studies are rather inconclusive and there are still some gaps that need to be filled in order to clarify the picture of prosodic perception deficits in autism.

Paul et al. (2005) and Peppé et al. (2007) found ***contrastive focus*** to be an area of difficulty for individuals with HFA and AS. The autistic participants in these studies demonstrated inappropriate comprehension of sentences containing focused phrases. The methodologies used in these studies are important for evaluating their results. In Paul et al.'s task 27 participants with ASD (HFA, AS and PDD, age 14-21) were asked to silently read two sentences from an answer sheet (e.g. (1) *'I waited for you out back'* **and** (2) *'I waited by the grocery store'* (Paul et al. 2005, p. 217)). The participants were then instructed to listen to a prerecorded stimulus of a sentence (**either** *'Go in [FRONT]$_F$ of the bank, I said'* **or** *'Go in front of the [BANK]$_F$, I said'*). The participants were asked to choose out of the two written sentences the one that should have come before the sentence that was auditorily presented (by marking the correct sentence in their answer sheet). Besides the fact that this task heavily relies on reading skills and that there was no confirmation that participants appropriately read the context sentences, this task is problematic in several other aspects. Firstly, it requires the participants to hold the auditory stimulus in memory for relatively long time in order to evaluate the appropriateness of the dialogue with both written sentences (sentence (1) and (2) in the example above). Secondly, based on the auditory fragment of a dialogue the participants were asked to go back and indicate the correct context in which it was uttered. This is a rather complex metalingual operation; hence, the nature of the task might pose an additional difficulty.

In Peppé et al.'s (2007) focus reception task, two patches of color were presented on a computer screen (e.g. a *blue* patch and a *black* patch). The participants (31 children with HFA, age 6;10-13;6) were then told a background story according to which the recorded person (the female speaker in the audio stimulus that they were about to hear) has purchased socks of different colors, but when she arrived home she found that she forgot to purchase one color. The participant then listened to an auditory target-sentence (**either** *'I wanted [BLUE]$_F$ and black socks'* **or** *'I wanted blue and [BLACK]$_F$ socks'*; Peppé et al. 2007, p. 1028) and were asked to indicate the color that the speaker forgot to buy by choosing the right color out of the two that appeared on the screen (*blue* for the first sentence and *black* for the second). This task too has

some weaknesses that might have affected the participants' performance. First, syntactic constructions that include a sequence of adjectives separated with a coordinator are more naturally interpreted as coordinate adjectives that modify the same noun and not as a conjunction at the higher level of NPs (with a nominal ellipsis of *socks*). Therefore, the target sentences are somewhat ambiguous and might sound rather unnatural in the context of the instructions. Second, the visual context in this task (the two colors that appear on the screen) was, too, rather ambiguous, in pragmatic terms. The natural visual context for uttering the first target-sentence (*'I wanted [BLUE]$_F$ and black socks'*) is one in which the speaker observes the socks she **has** bought (for the argument sake: *white* socks and *black* socks) and realize that she purchased *white* colored socks instead of *blue* socks. The focus on *blue* in the first target-sentence make salient a set of alternative colors that the speaker might have bought and implies that the color *blue* should be absent from this set. The visual context, however, is not compatible with these implications in that it presents the color *blue*. The participants in this study were in a position in which they were asked to indicate the color that the speaker **forgot** to buy, hence, the color that should be absent in terms of the visual pragmatic context in which the sentence is uttered. Indicating the *blue* patch of color in the presence of a contrastive focus on the word *blue* could be a rather counterintuitive act in the given context. The methodological limitations in these tasks may lead to erroneous interpretation of the results.

Studies that investigated the perception of the grammatical aspect of ***lexical stress*** indicate that autistic participants were able to distinguish ambiguous words that differ in stress pattern. Chevallier et al. (2009) found that 17 adolescents with AS (age 11;1-17;10) were no different than 17 control participants (age: 11;6-16;8) in their ability to rely on stress pattern in order to select the appropriate pronunciation of a dissyllabic word within the context of a sentence. Grossman et al. (2010) reveals that like control participants, the 16 autistic participants in their study (age 7;6-17) were more accurate in identifying trochaic stress patterns, which form the dominant stress pattern of nouns in English, than in perceiving the less frequent Iambic stress patterns. To the best of my knowledge Paul et al. (2005) is the only study that indicates performance differences between ASD participants and controls in a *lexical stress reception task*. The performance of the ASD group in this task was defined as *approaching significance*; however, due to a relatively high p value (p=0.12) these results might be open to more than one interpretation

With regard to the grammatical aspect of ***phrasing***, most studies do not indicate pronounced difficulties in the ability of autistic participants to perceive grammatical parsing that relies on prosody. In a syntactic phrasing reception task, Paul et al. (2005) found that both ASD group and controls were equally able to rely on prosodic cues such as rhythm and pauses in the interpretation of sentence phrase structure. The participants heard an auditory stimulus of a sentence in which the pattern of pauses affect syntactic segmentation, such as *'Ellen, the dentist is here'* vs. *'Ellen, the dentist, is here'*. In the first sentence, *'Ellen'* is addressed by the speaker and being told that *'the dentist is here'*. In this case there is no coreference between *'Ellen'* and *'the dentist'*. In the second sentence, however, the two phrases *'Ellen'* and *'the dentist'* are in apposition. The NP *'the dentist'* serves to identify the NP *'Ellen'*, hence, *'Ellen'* and *'the dentist'* corefer. The structure and meaning of these two utterances is, therefore, directly affected by prosody. The performance of the ASD groups in Peppé et al. (2007), Chevallier et al (2009) and Grossman et al. (2010) was consistent with Paul et al.'s findings. The ASD groups in these studies were found to be unimpaired in their ability to identify phrase boundaries that are signaled by prosody in order to differentiate compounds (e.g. greenhouse / dragonfly / chocolate-cake) from independent phrases (e.g. green house / dragon, fly / chocolate, cake). In contrast, in Diehl et al.'s (2008) study, a group of 21 adolescents with HFA (age 11-19) performed significantly worse than controls (N=22, age 11-19) in an act-out task in which the interpreting of ambiguous structures was based solely on prosodic phrasing (e.g. (1) *'put the dog in the basket, on the star'* vs. (2) *'put the dog, in the basket on the star'*). However, the HFA difficulties emerged only in sentences with NP-attachment structure, as the first sentence in the example above, whereas for the second type of ambiguous sentences with VP-attachment structures the HFA group's performance was at ceiling, and no different than control. The authors suggested, therefore, that the participants' performance might not reflect a prosodic deficit but rather a bias resulting from the nature of the verb *put* for which the common order of arguments is an NP immediately followed by a PP.

When it comes to the comprehension of ***interrogatives*** and ***declaratives***, results are again rather inconclusive. Both Paul et al.'s (2005) and Chevallier et al.'s (2009) studies found no obvious differences in ASD groups' ability to distinguish questions from statements. Peppé et al. (2007), however, report that some of the HFA children in their study (12.9%) systematically misjudged questions as statements. In this

respect it should be mentioned that the question-statement reception tasks in these three studies differed in several aspects that might have affected the participants' performance. The tasks in both Paul et al.'s and Chevallier et al.'s studies included sentences as stimuli and required the participants to label the target-sentences (in Paul et al. *'was the speaker asking or telling?'*, in Chevallier et al. *'did the speaker sound sure or unsure?'*). Peppé et al.'s task included word-stimuli (and not sentence stimuli) and involved the use of pictures to represent the acts of *asking* and *telling*. For example, for the auditory question stimulus *'carrots?'* the participants had to choose between two pictures: *(1) a picture of a person offering carrots on a plate*, and *(2) a picture of a person reading from a book with carrots in a call-out* (Peppé et al. 2007, p.1027). Since the autistic's ability to interpret body gestures and to understand social situations is known to be irregular to some extent, it could be that the notion of *'offering'* as visually reflected in a picture was more confusing for the autistic group. This assumption could also account for the direction of misjudgments reported by Peppé et al. (judging questions as statements and not the other way around). It could be, therefore, that factors other than prosody might have affected the participants' performance in this task. This assumption could gain some additional support from Erwin et al.'s (1991) brain imaging study. In an Event-Related Potential (ERP) study of 11 HFA adults (age 17-39), P3 potential was measured as an index for involuntary attention switch in the presence of a rare stimulus - a *declarative utterance* (e.g. *'Bob!'*) that appeared in fifth of the trials (while the stimuli in all other trials were *interrogative utterances*, e.g. *'Bob?'*). Behavioral responses were also measured based on accuracy rates (pressing a button when rare stimuli are recognized). Both measurements indicated intact processing of questions and statements.

The vast majority of studies regarding prosody perception in autism has focused on ***affective prosody*** and investigated the ability of autistic individuals to recognize and interpret mental states, emotions and moods that are conveyed in speech. And yet, the body of research assessing affective prosody perception in autism is inconclusive. A receptive deficit that has been identified in several of these studies has led some of the researches to stipulate a close connection between the observed prosodic impairments and more general deficits in cognitive and mental abilities such as Theory of Mind or empathizing (Rutherford et al. 2002, Golan et al. 2007). Other studies, however, did not find obvious difficulties in affective prosody perception in children and adults with ASD.

Peppé et al.'s (2007) findings indicate that autistic children were less competent than their TD peers in a matching task of simple emotions in single word stimuli (indicating *liking* or *disliking*) with pictures of facial expressions. As noted by Grossmann et al. (2010), single-word stimuli substantially limit the volume of prosodic information in comparison with the more natural manifestation of emotion in sentence-length utterances. Additionally, the ability to decode emotions from facial expression is known to be defected, to some extent, in ASD, hence it might be that face recognition abilities acted as an intervening factor, obscuring the effect of prosody in this task (e.g. Braverman et al. 1989). Lindner and Rosén (2006) have controlled for this aspect and shown that 14 children with AS (age: 5-16) were less able than their TD peers (N=16, age: 5-16) to rely on prosody in labeling simple emotions from audiotaped social scenes with neutral semantic content. The AS participants in Lindner and Rosén's study also displayed difficulties in decoding emotions from static (picture) and dynamic (muted videotaped) facial expressions. Rutherford et al. (2002) and Golan et al. (2007) investigated the ability of adults with HFA and AS to select the most suitable word (out of 2 words in Rutherford at al. (2002) and out of 4 in the revised version of the test in Golan et al (2007)) to describe complex emotions conveyed in segments of dialogues from dramatic audio books. When compared with controls, the ASD groups of adults in these studies showed impaired ability to identify a variety of vocally expressed emotions (N=19, age: 16-59 in Rutherfrod et al. 2002, N=50, age: 17;4-49;9 in Golan et al 2007). However, some methodological weaknesses of this task should be considered. Due to the source of the stimuli the utterances varied in lexical content, length, pitch range, and voice quality (among other features) and at least for some of the stimuli, the semantic and lexical content of the target auditory-utterance was more closely associated with one of the description words that were given as possible answers. Additionally, the description words that were used in this task (mostly adjectives) differed in frequency of use and some were in fact quite rare (e.g. *'defiant' 'derogatory', 'aggrieved' 'contemplative'* or *'lured'*). The participants were given a handout with words' definitions beforehand and according to the authors' report, no participant asked for clarifications. Since no direct assessment of participants' knowledge of words' meanings was carried, the interpretation and understanding of these terms might have differed across participants. Due to these issues it seems that factors, other than prosody might have

affected the selection of the mentalistic word that best describes the speakers' emotion in this task.

In contrast to the above studies, several other investigations did not find obvious differences between autistic participants and control participants in affect reception tasks. Boucher et al. (2000) for instance, found that children with autism were as able as their control peers to identify and label six basic emotions (happiness, sadness, disgust, fear, anger, and surprise) based solely on the prosody of single-word stimuli (e.g. days of the week or months of the year). The same group of autistic children showed poor performance in matching the same auditory stimuli to a picture of an emotional facial expression. In Erwin et al.'s ERP study (1991) the group of HFA adults did not differ from control in their behavioral and electrophysiological response to prosodic affective pairs (e.g. the word *'Bob'* said in an *angry* or a *happy* manner), indicating normal acoustic and cognitive recognition and interpretation of prosodic information. In line with these results, Paul et al. (2005) found the ASD group's ability to label moods (*exited* vs. *calm*) in target sentences to be equal to that of control participants and Grossman et al. (2010) found that the performance of the HFA group in their study did not differ from controls in receptive tasks of affective prosody. The children and adolescents in this study were as able as controls to identify *happy, sad*, and *neutral* emotions in filtered sentences.

In summary, researches of prosody in autism and particularly of prosody comprehension are rather scarce. Recent studies aim to capture a more comprehensive picture of prosody perception in autism, however, inconsistent findings making cross-study comparisons challenging. The differences between the above results might stem from the use of varied samples (in terms of age, size and clinical diagnosis) as well as varied stimuli and methodologies.

1.2.5. *Theory of mind* and *Prosody* in autism

Theory of Mind is the ability of a person to theorize the unobservable aspects of his and other's mind. This cognitive ability enables a person to predict and reason people's behavior in various social situations based on inferences regarding their mental states, intentions and beliefs (Premack and Woodruff 1978). It is argued that typically developed children acquire *Theory of Mind* skills naturally between the ages 3 and 5 and that these skills are a crucial condition for constructing appropriate communication and social behavior (Wellman et al. 2001). *Theory of Mind* has been

taken by many to be a core deficit in autism. While several cognitive theories have aimed to explain the social and communicative features of the autistic population (e.g. *the Weak Central Coherence theory* (Frith 1989, Happé 1999), *the theory of Executive Dysfunction* (Hughes et al. 1994, Hill 2004)) *Theory of Mind* is considered the most dominant and widely applied theory in the research of the autistic cognitive deficiency. The *Theory of Mind hypothesis* (Baron-Cohen et al. 1985) suggests that the communicative and social impairments in autism spectrum disorders are the result of a cognitive deficit in imputing mental states to others.

An important step in the development process of *Theory of Mind* skills is the acquisition of the ability to attribute *false beliefs*, hence, to understand that others may hold knowledge and beliefs that are different from, and in some cases contradictory to one's own. The most common *false belief* task that aims to evaluate *Theory of Mind* skills was devised by Wimmer and Perner (1983). In this task the participant are presented with a scene, usually played by two dolls. The sequence of events leads to a state in which one doll holds a *false belief* about the location of an object, since it was unaware to the fact that the object was moved by the other doll. Hence, the doll's beliefs about the object's location are incompatible with its real location and with the knowledge of the participants', who witnessed the relocation of the object in real time. The participants are then asked to predict where the doll will look for the object. To pass the task, the participants must recognize that the doll do not share their mental representation of the situation.

The results of *false-belief* tasks in various studies have been fairly consistent, indicating that typically developed children are able to accomplish these tasks by the age of 5. In contrast, 80% of the autistic participants in Baron-Cohen et al.'s (1985) study (16 out of 20 participants, age: 6;1-16;6) failed the false belief task, leading the authors to suggest the *Theory of Mind hypothesis* according to which autistic individuals suffer from a lack of *Theory of Mind*. These influential findings have triggered numerous investigations of *Theory of Mind* abilities in autism using various devices. However, not all the results of these sequential studies were in accordance with Baron-Cohen et al.'s hypothesis. Happé (1994), for instance, viewed the fact that 20% of autistic individuals have shown to pass false-belief tasks as an inherent problem for the universality argument of the *Theory of Mind Hypothesis*. Bowler's study (1992) also challenged the idea that autism spectrum disorders could be explained as impairment in *Theory of mind* since 93% of the AS adolescent

participants in his study successfully accomplished first-order false-belief task and 73% passed a second-order false belief task. These studies, among others elicited a change of assumptions regarding the nature of the *ToM* deficit in autism. *Theory of Mind* that was traditionally viewed binary as present or absent is now taken to exist on a continuum (a skill that one can have more or less of). These assumptions have led to the development of advanced tasks that were designed to identify more subtle *Theory of Mind* deficits in older and higher functioning individuals (e.g. the *Strange situation* task (Happé 1994) the *Reading the Mind in the Eyes* task (Baron-Cohen et al. 1997), *Faux Pas* tasks (Baron-Cohen et al. 1999) and the *Reading the Mind in the Voice* task (Rutherford et al. 2002, Golan et al. 2007 among other tasks). These advanced tasks differ from Wimmer and Perner's original tasks in that they involve face recognition as well as various aspects of language processing, including prosody perception (Rajendran and Mitchell 2007).

Some attempts have been made to directly link deficits in *prosody perception* to impaired *Theory of Mind*. The results of Rutherford et al.'s (2002) and Golan et al.'s (2007) studies indicate that autistic participants differ from typically developed controls in recognizing affect based on vocal cues. The *Reading the Mind in the Voice* task that was presented in these studies was based on the assumption that understanding *affective prosody* is a *Theory of Mind* skill. The lack of ability to infer vocally expressed affect was viewed by the authors as a symptom of a general impairment in participants' ability to relate mental states to others and therefore it was suggested that a deficit in *affective prosody* can serve as an indication for *Theory of Mind* deficiency. This view was shared by other studies, such as McCann et al. (2007) which also surmised that impaired *Theory of Mind* could be the cause of prosodic deficits.

These assumptions, however, were assessed and contradicted by Chevallier et al.'s study (2011). The interpretation of prosodic deficits in the context of *Theory of Mind* together with the view of *Theory of Mind* impairments as a continuum, predicts that autistic participants will be more impaired as *Theory of Mind* requirements increase. In Chevallier et al.'s study a group of 16-20 autistic adolescents (AS and HFA age: ~12-16) participated in three experiments. The participants' performance was evaluated (by measures of reaction times and accuracy rates) in a range of five diverse categories of vocal cues, requiring different levels of 'mindreading': a *manner of speech* category that rely on external cues (e.g. screaming vs. whispering) a

category of vocal cues of *physical states* (e.g. tired vs. cold), a *Basic emotion* category (e.g. happy vs. sad), a *Social emotion* category (e.g. guilty vs. proud) that require first-order inferences, and a fifth category of more complex vocal cues requiring *Second-order mental state* inferences (e.g. admiration vs. irony). The results of this study did not indicate any specific impairment in processing vocal cues that are related to *Theory of Mind*. The autistic participants were as accurate as the control group in all categories across the three experiments and they were not specifically slowed down by categories that required excessive 'mindreading'. These finding suggest that the autistic participants were as capable as controls to *'read the mind in the voice'*.

To conclude, the past decades of extensive research on the cognitive impairment in autism regards the difficulty in understanding mental states as one of the core deficits in autism. However, while the *Theory of Mind* hypothesis can explain some of the observed autistic characteristics, it seems that it cannot exclusively explain the full range of symptoms and their diverse expressions. The nature of the relation between *Theory of Mind* skills, affect processing and prosody should therefore be further investigated.

1.3. Open questions and Research objectives

The present study aims to assess AS individuals' ability to distinguish and comprehend various prosodic patterns that serve different linguistic functions.

As emerges from the results reported above, the literature regarding prosody in autism is rather inconsistent. This inconsistency could be at least partially attributed to the fact that methodologies, stimuli selection and research groups varied significantly across studies. The current work attempts to address some of these issues.

Group differences between and within studies in terms of *age* and *clinical definition,* might account for some of the cross-study variations that were obtained. Paccia and Curcio's (1982) test group, for instance, included autistic children between the ages 6;11 and 16;10, Peppé et al. (2007) tested HFA children between the ages 6;1 and 13;6, Chevallier et al. (2009) tested adolescents between the ages 11;1 and 17;10, and Erwin et al. (1991) tested adults at the ages 17 to 39. Furthermore, some of these studies involved participants with rather broad clinical diagnoses in terms of the autistic spectrum. Paul et al. (2005), for instance, included in their autistic group teenagers with HFA, AS and PDD-NOS. Since it was established that prosodic abilities are gradually developed and continue to change until relatively late stages of

language acquisition[8] (Wells et al. 2004), and since some differences in linguistic abilities were assumed to characterize different clinical groups such as AS and HFA, the above differences might account for some of the inconsistency that was found in the literature.

In order to address these issues, the participants in the present study were all adult individuals with Asperger syndrome (age: 22-38**)** and therefore were expected to have reached maturity of prosodic abilities and to be relatively less heterogeneous in terms of diagnostic criteria.

Additionally, only few studies systematically evaluated different functions of prosody. Many studies of prosody in autism have focused on a single aspect of prosody, making it hard to conclude upon other prosodic patterns and to define the scope of the autistic prosodic deficit. Several recent studies, however, have designed complex and extensive arrays of tasks in order to reach a more comprehensive picture of prosodic skills in autism. Paul et al. (2005) introduced a set of twelve tasks that aimed to assess the autistic children's production and perception of three prosodic aspects (stress, intonation and phrasing) that serve grammatical and pragmatic/affective functions. Peppé et al. (2007) and McCann et al. (2007) evaluated a group of HFA children using the Profiling Elements of Prosodic Systems in Children (PEPS–C, Peppé and McCann 2003) that was designed to assess expression and comprehension of several prosodic aspects (interaction (turn-end), affect, chunking and focus). However, thought thorough and rigorous, the above mentioned batteries had some drawbacks (as noted in sections 1.2.3-1.2.4) in terms of experimental design (e.g. combining different prosodic patterns in one task), the involvement of non-prosodic modules (e.g. reading skills, face recognition and memory capacity) the selection of stimuli (e.g. single word vs. complete sentences) and the presence of infelicitous pragmatic contexts or ambiguous instructions that could lead to potential interpretational difficulties. Additionally, in both Paul et al.'s and Peppé et al.'s studies participants were directed to pay attention to prosodic cues throughout the tasks. As a part of the training trials that preceded each task, participants in both studies were given feedback regarding their accuracy and were instructed as to the expected answer. The above issues therefore should be taken under consideration in evaluating the findings of these studies.

[8] According to Wells et al. (2004) some aspects of prosody perception continue to develop through the school years up to the age of 11.

In order to address some of these issues the prosodic tasks in the present study attempt to isolate the influence of prosody (hence, no reading skills, excessive memory load or face recognition was required) and an effort was made in order to provide a felicitous pragmatic context for the target-stimuli. Additionally, the same prosodic aspects were assessed in discrimination and comprehension tasks with both word- and sentence-level stimuli, and control conditions were included to make sure that the participants will be unaware to the tasks' objectives.

Another issue that is addressed in the present study is the potential correlation of a prosodic deficit with other cognitive and linguistic skills. Different studies indicated various degrees of correlation between the prosodic impairments of autistic individuals and their expressive and receptive language abilities and verbal IQ (McCann et al. 2007). In order to address this assumption, the AS group in the present study included only individuals for which verbal IQ scores were found to be within the norm. Additionally, a battery of syntactic and lexical tasks, as well as phonological working memory assessment, were included in this study in order to control for individual differences in linguistic and cognitive abilities within the AS test group.

The present study also addresses the suggestion that impaired prosody could be the outcome of a more general cognitive disorder. Some of the accounts for the prosodic deficit in autism explain the prosodic abnormalities as a manifestation of *Theory of Mind* deficiency or of a general deficit in affect perception or pragmatic competence. However, most studies, even those which argued for this dependency, do not evaluate pragmatic competence or *Theory of Mind* skills as a part of the experimental procedure. In order to evaluate these suggestions, the current study includes both pragmatic tasks and comprehensive *Theory of Mind* evaluation.

To conclude, this study incorporates a new prosody assessment procedure that aims to evaluate various aspects of receptive prosody and attempts to address some of the open questions regarding the scope and sources of the prosodic deficit in autism.

2. General method

This section provides details regarding participants in the test group and comparison group, the general testing procedure and the statistical analysis of the obtained results.

2.1. Participants

A group of 10 participants with Asperger syndrome and a control group of 30 typically developed individuals participated in the study.

2.1.1. ***Asperger syndrome test group***: The test group in this study is comprised of 10 adults diagnosed with Asperger syndrome according to formal psychiatric evaluations (based on DSM IV diagnostic criteria). The Asperger test group (henceforth AS test-group) consisted of 8 males and 2 females aged 22-38 (Mean age 30;3, SD = 4;2). All participants were native monolingual speakers of Hebrew with normal or corrected to normal vision and with no history of hearing impairments or major physical disability. All 10 participants completed full high school education; most of them have full or partial matriculation certificate. The participants live in an assisted living residence in Tel-Aviv.

The study included a preliminary step of evaluating the participants' verbal IQ (VIQ) using the verbal section of the Hebrew adaptation of the Wechsler Adult Intelligence Scale – Third Edition (WAIS-III, Wechsler 1997). This test was conducted by a psychology Ph.D. student formally trained to conduct and analyze IQ tests. Since the study involved mainly linguistic tasks, Verbal IQ was controlled for, and only those participants within the normal range of VIQ (80-120) were included in the test group. It should be noted that the participants' scores showed substantial variation with an average group score above the median point of average range (104.3) and a standard deviation of 11.9.

The results of the group analysis of the AS test group, which will be delivered in sections 5 and 6 below, is based on the performance of nine out of the ten participants in this group. The results of one participant (participant no. 8, see (8) below) were analyzed separately due to substantial differences in comparison with both the AS test group and the control group. The unique performance pattern of this participant, which was dissimilar in quantity and in quality of errors to that of his peers, will be discussed in detail in the *individual analysis* in section 8.

Table (8) presents background information regarding individual participants of the AS test group.

(8) AS test group participants

Participant	Sex	Age	VIQ score	Level of high-school education*	Other disabilities
1	M	34	99	Full	OCD, Schizophrenia
2	M	34	113	Full	Anxiety disorder
3	M	29	116	Full	ADHD
4	M	30	87	Partial	Not reported
5	M	30	113	Full	Learning Disabilities
6	M	30	110	Full	Not reported
7	F	22	99	Partial	Anxiety disorder
8	M	26	80	Full	ADHD, Learning Disabilities
9	M	38	113	Full	Not reported
10	F	31	113	Partial	Not reported

*__Full__ matriculation certificate; **Partial** matriculation certificate (12 years schooling)

2.1.2. ***Control group participants:*** Thirty typically developed adults (15 males and 15 females, Mean age of 25;1, SD = 4;0) were recruited as a comparison group. The vast majority of the participants in this group were first year B.A. students from various departments in Tel Aviv University (middle-east studies, psychology, linguistics, biology, computer science). All control participants were native speakers of Hebrew and reported of no history of speech, language, or learning disabilities. Not all 30 control participants took part in all the experiment's tasks, thus the size of the control group varies from 15 to 27 in the different tasks. Three control participants were excluded from the analysis. One of which reported of having a rich background in linguistics studies and the other two reported of having severe learning disabilities.

2.2. General procedure and experimental array

The study comprised of four test batteries. The first and main battery, which was specially designed for the present study, is the **Receptive Prosody battery - *PROSA***, a novel array of tasks designed to assess receptive prosodic abilities. The *PROSA* battery is presented and discussed in detail in §4-§7.

Task description and results of the other three batteries are presented in §3. These additional batteries were used to achieve more adequate picture of the participants' linguistic and cognitive abilities. The **aTOMic battery** (Balaban 2010,

Balaban and Friedmann 2010) consists of 8 traditional ToM tasks that aim to detect deficits in ToM skills. The **working memory assessment - FriGvi** (Friedmann and Gvion 2003) comprised of 4 tasks and aim to evaluate participants' phonological memory skills. The **language skills evaluation** is a set of 9 linguistic tasks that are aimed to identify reading impairments and grammatical deficient of syntax, lexicon and related operations (Friedmann 1998, 2000, Friedmann and Gvion 2003, Gvion and Friedmann 2008, Biran and Friedmann 2004, 2005). This unit of language skills evaluation also included two pragmatic tests specifically designed for the present study. Below is a list of the applied batteries:

Throughout the experimental sessions the *PROSA* tasks were intertwined with non-prosodic tasks from other batteries so that the tasks did not call explicit attention to prosody.

For the administration of the experiment, participants were seen individually, three to four times. Each session took approximately 60 minutes. All the participants were paid 60 NIS (approximately 17 USD) for every session. The experiment was conducted in a quiet office, located in the participants' residence for the AS group and in an office at the university for the control group. Before each task the experimenter (the author) gave each participant a detailed explanation of the task.

2.3. Statistical analysis

Comparisons of the AS test-group and control group's performance were made using *Mann Whitney* test, a nonparametric test for the significance of the difference between distributions of two random, independent, samples. This test allows comparing two groups or conditions without assuming normal distribution or equal variance.

The effect of the difference between two (or more) conditions and the possible interactions of *group* and *condition* were analyzed using *Repeated Measures Analysis of Variance (rANOVA)* that enables a comparison of the same participant's response across conditions.

Crawford-Howell *t* test for case-control comparisons (Crawford and Howell, 1998, Crawford and Garthwaite 2002) was used for comparing a single subject to a group. This test enables to detect whether individual participant's performance is significantly different from the control group's average.

Though for some of the PROSA tasks an a priori hypothesis regarding the direction of potential difference between groups or conditions was assumed, in order

to avoid missing a possible effect in the other direction all *p* values reported are the result of a two-tailed comparison. Significant difference is stated for any *p* value under 0.05.

In terms of statistical significance, the results of comparisons *per subject* were in accordance with the results of comparisons *per item* with the exception of few isolated cases. Therefore, for the clarity of exposition, all results reported refer to comparisons *per subject* unless otherwise specified.

3. Evaluating linguistic and cognitive abilities

This section provides task description and results of the theory of mind evaluation (§3.1-§3.2), working memory evaluation (§3.3-§3.4), and language skills evaluation (§3.5-§3.6). As noted above, these tests were used in order to assess the linguistic and cognitive skills of the participants in this study.

3.1. Theory of mind evaluation

The *aTOMic battery* (Balaban 2010, Balaban and Friedmann 2010) was designed to detect and define impaired Theory of Mind (ToM) skills and was found effective in detecting ToM deficits in adults that suffer from a brain damage to their right hemisphere (Balaban 2010, Balaban and Friedmann 2010). The aToMic battery includes eight categories of tests which cover various aspects of the ToM ability. The battery, as detailed in (9) below, consists of classic ToM tests (9a-b), such as the first and second order false belief tests, as well as more sensitive fine-tuned tests (9c-h), which require a higher level of ToM abilities (Happé 1994, Baron-Cohen et al. 1999, Rutherford et al. 2002). All tests were adapted to suit adults and each category was tested by at least two items. The battery included a total of 20 items, short texts and images that describe certain state of affairs, to which the participants were asked to respond. Following each item, the participants were presented with several questions; reading comprehension and memory questions to verify that the participant read and understood the text, and ToM questions regarding the intentions, thoughts, emotions or state of mind of the protagonist in the scene. All items were presented as written texts using a computer screen and were not read to the participants in order to avoid the possible influence of prosodic information on the participants' ToM performance.

(9) The aTOMic battery

	Test	General test description
a.	**First order false belief** (2 items)	The participants were presented with a short paragraph describing a change of location of an item. The change takes place without the protagonist's knowledge. Based on this false belief situation, participants were asked to anticipate where the protagonist will look for the item.
b.	**Second order false belief** (2 items)	The participants were presented with a short paragraph describing a sequence of events in which the protagonist is not aware to a change in the state of knowledge of a second character. The participants were asked to predict the protagonist's action based on its false belief regarding the second character knowledge.
c.	**Instruction** (2 items)	The participants were presented with a short paragraph describing an event of teaching, in which the teacher mistakenly led to think that the pupil knows the act to be taught, when in fact they did not learn it (or alternatively - the teacher mistakenly thinks that the pupil does not know the act when in fact they have learned it). The participants were asked to predict whether the teacher will try to teach the pupil the relevant act or not.
d.	**Knowledge gaps** (2 items)	The participants were presented with a short paragraph describing an interaction between two characters that was based on a misunderstanding. The participants were asked to explain the characters' actions and the motives for their behavior.
e.	**Faux pas** (2 items)	The participants were presented with a short paragraph describing a rude behavior of one of the characters that is a result of the character's lack of knowledge regarding the course of events. The participants were asked to explain the character's misbehavior.
f.	**Surprise** (2 items)	The participants were presented with a short paragraph describing a character acting as if it was surprised although it had found out about the plan to surprise her. The participants were asked to explain the character's 'fake surprise'.
g.	**Cartoon** (2 items)	The participants were presented with a cartoon showing a strange occurrence. The participants were asked to explain the situation in the cartoon and to account for the figures' actions. The key for understanding the occurrence in the cartoon was in perceiving the thoughts and the intentions of the figures which were presented in it.
h.	**Emotional false belief** (6 items)	The participants were presented with a short paragraph describing a character that was hiding its real emotion. The participants were asked to explain the character's behavior and to account for its true feeling. In order to do so, the participants had to understand a misleading emotional display (Gross and Harris 1988)

3.2. Theory of mind evaluation – results

None of the AS participants showed response pattern that was significantly unusual in comparison with a control group of 13 participants (Mean age = 26;2, SD = 4;4) in the current study as well as in comparison with the control group of 14 adults that participated in Balaban's study (2010), in which similar tasks with minor differences were used.

Following Balaban's (2010) coding system, memory questions were not calculated as a part of the items score and were used solely to verify the participants' understanding of the text. The ToM target questions included both YES/NO questions as well as open questions that demanded justifications and explanations. These questions were coded as either correct or incorrect (1/0). A score of 1 was achieved only if the participant responded correctly to the YES/NO question and provided an appropriate justification for the open questions.

The following table presents the average score of the AS participants in each task. Every slot displays a figure between 0-1 that stands for the average score of all items of a specific task.

(10) Comparison of AS test-group and control groups scores - The aTOMic battery

Task / Participant	1st order f.b.	2nd order f.b.	Inst	Know gaps	Faux pas[9]	Surp	Emot f.b.	Average per participant
1	1	0	1	1	1	1	1	**0.86**
2	1	1	0.5	0.5	1	1	1	**0.86**
3	1	1	1	1	1	1	1	**1.00**
4	1	0	1	0.5	1	1	1	**0.79**
5	1	0	1	1	1	0.5	0.83	**0.76**
6	1	1	1	1	1	1	0.83	**0.98**
7	1	1	1	1	1	1	0.83	**0.98**
8	0	1	1	0.5	1	1	0.83	**0.76**
9	1	1	1	1	1	1	1	**1.00**
10	1	1	1	1	1	1	0.83	**0.98**
Average score AS group n=10	**0.90**	**0.70**	**0.95**	**0.85**	**1.00**	**0.95**	**0.92**	**0.90**
SD	0.30	0.46	0.15	0.23	0.00	0.15	0.08	0.10
Average score Control group n=13	**1.00**	**0.69**	**0.88**	**0.92**	**1.00**	**1.00**	**0.85**	**0.91**
SD	0.00	0.46	0.29	0.18	0.00	0.00	0.28	0.10
Average score Control group Balaban (2010) n=14	**1.00**	**0.89[10]**	**0.82**	**1.00**	**0.93**	**0.96**	**1.00**	**0.94[11]**

f.b. = false belief, **Inst** = instruction, **Know gaps** = knowledge gaps, **Surp** = surprise, **Emot f.b** = emotional false belief

As shown above, none of the participants demonstrated response pattern that could be considered a result of a systematic ToM failure, and despite within group differences between the members of the AS test-group, none of the participants performed significantly poorer when compared to the control norm. The *p* value for the

[9] One Faux pas item was excluded from the analysis due to technical issues in the conduction of the task. Therefore, the scores in this column represent one item instead of two.
[10] After consulting Noga Balaban regarding some minor adjustments of the aTOMic battery for the use of the present study, it was decided to apply some minor changes to the 2nd order false belief task's items. The observed difference between the two control groups in the 2nd order false belief task could be the result of these changes.
[11] SD=0.06

difference between the performance of participants 5 and 8, who gained the lowest average score (0.76), and the control norm is p=0.174 (in a two-tailed Crawford-Howell t-test). In terms of group performance, the AS test-group does not significantly differ from both control groups in any of the tasks detailed in (10).

The Cartoon task that is presented separately in (11), was the only task in which obvious differences were found between the groups. As evident from (11), the AS test group scored significantly lower on this task than both control groups.

(11) Comparison of AS test-group and control groups scores – Cartoon task

Task / Participant	Shark cartoon	Rooster cartoon	Total
Average score AS test group, (SD) n=10	0.50 (0.50)	0.10 (0.30)	0.30 (0.33)
Average score Control group (SD) n=13	0.85 (0.36)	0.85 (0.36)	0.85 (0.36)
Average score Control group Balaban (2010) n=14	1.00	0.86	0.93

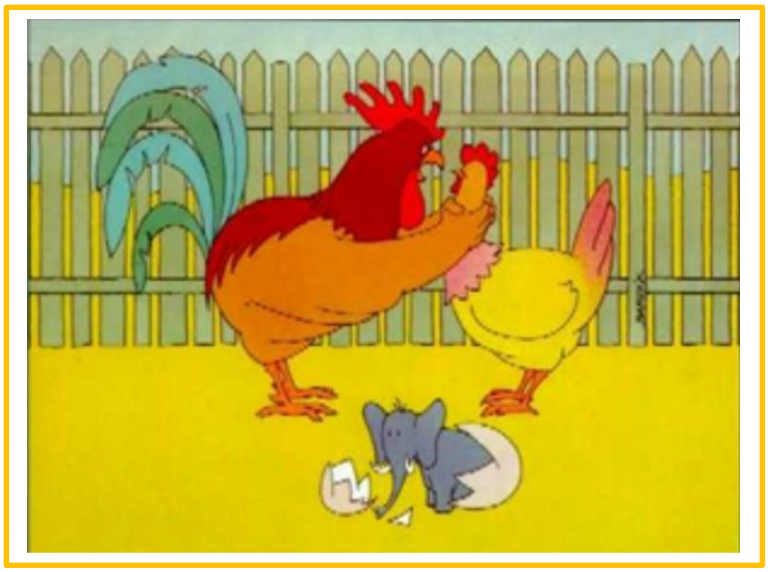
However, it seems that this difference, which might reflect a ToM deficiency, could be explained, in this case, as a result of world knowledge lacunas that might stem from insufficient social experience.

Two cartoons were presented in this task. One cartoon (12a) displayed a slyly smiling shark, holding out a stick that looks like the hand of a drowning man, while a man on a nearby shore is getting ready to jump in to the water to save what appeared to be a man in need. In the second cartoon (12b), a furious rooster stands next to a baby-elephant hatching from an egg, and strangles a hen.

(12) aTOMic battery – Cartoon stimuli

a. Shark cartoon

b. Rooster cartoon



Besides the need to infer the thoughts and the mental state of the protagonists in these animations, an appropriate description of the cartoons requires understanding the concepts of deception, infidelity and adultery (the rooster cartoon in particular). It could be that the AS participants, that live in assisted living residence and lack the social experience of typical adults, found it difficult to identify the humoristic aspects in the cartoons, aspects that clearly rely on interpreting delicate social and intimate situations and not solely depend on inferring the mind of the other. An appropriate

description of these cartoons involve mentioning the shark's malignancy and sophistication in trying to lure the man into water, and the hen's infidelity that resulted in a baby-elephant instead of a chick, concepts that might slip under the incompetent social-radar of the AS participants.

This assumption could be strengthened by some of the inappropriate explanations (scored 0) supplied by the AS participants in response to the two cartoons (13a-b). These responses indicate that the participants were in fact relating mental states, thoughts and intentions to the behavior of the protagonists, though, not the expected intentions, in the case of the following examples.

(13) Examples for inappropriate responses by the AS participants

a. Shark cartoon

Participant	**Response**
4	*'The man sees the shark crying for help. He wants to help him. He is coming to help him but he is in fact a fish, he knows how to swim'.*
7	*'A whale holding up a stick with a hand on it and a man is getting undressed. Maybe the whale wants to take his pants - That is why he is holding that hand!'*

b. Rooster cartoon

Participant	**Response**
8	*'What does an elephant do near a rooster? Unless… somebody has swapped his eggs! It could be that he (pointing at the hen) tricked him, swapped his eggs, and now the rooster is strangling him because he has touched his chicks'*
7	*'An elephant is hatching from an egg. It looks bizarre the way it is drawn. Maybe she laid it, or she has mated with an elephant and it happened. Or maybe they have decided to adopt, it seems to me that he is about to kiss her'*

It is obvious from (13a) that participant 4, detected that the shark is crying for help, however, he missed his true vicious intentions and inferred his act as humoristic (since the shark can swim!). Participant 7 identified the animal as a whale and

inferred its intentions as somewhat naïve (stilling the man's pants). Participants 8 (13b) did not identify the illustration of the hen as representing a female-chicken and therefore missed the adultery aspect completely. However, both participants in (13b) gave interpretations that attribute complex emotions and intentions to the two characters.

Since a full and coherent interpretation of the situations in the above cartoons requires, at least to some extent, activation of ToM inferences, misunderstanding these situations could not directly point out a ToM disability. In addition, the fact that the cartoon task was the only ToM task in which the AS test-group performance differed from control suggests that abilities or knowledge that are not necessarily ToM related are the cause for these observed differences.

This assumption is also strengthened by the findings of Abramson's (2012) study, where the AS participants are reported to demonstrate irony comprehension abilities that were similar to those of their typically developed peers. It should be noted that 7 out of the 10 participants in the present study took part in Abramson's study and were not significantly different than control in interpreting ironic statements.

Various studies claim that the ability to infer ironic statements and understand figurative speech (such as metaphors) directly depend on ToM skills and involve meta-representational thinking, since the interpretation of these types of utterances rely on the ability to grasp speaker's intentions (e.g. Happé 1993, Colston and Gibbs 2002 among others). Happé's (1993) findings indicate that the interpretation of ironic statements requires second-order ToM skills, while first-order ToM skills are sufficient for metaphor comprehension. Based on these results, Happé (1993) argues for a correlation between severity of ToM deficit and inference abilities. The fact that 7 out of 10 AS participants in the present study were able to appropriately interpret ironic statements adds to the assumption that the AS test-group does not exhibit a severe loss of ToM skills.

Additional support for this assumption comes from assessing the participants' use of mental state verbs and mental state terms (e.g. *thinking, knowing, wanting*). It was suggested that ToM skills and the ability to represent the thought and intentions of others correlate with the use of cognition verbs in spontaneous speech (Astington, 1998). This association is expected to be expressed in irregular use and interpretation

of mental state verbs by individuals with impaired ToM skills (Balaban 2010). The present study did not include designated tasks for evaluation of mental state verbs comprehension or use. However, following Balaban's coding system, in addition to appropriateness, the responses of the AS test-group in the aTOMic battery were also graded for the use of mental state terms and were found to be no different than the responses of the control group in that respect.

In summary, evaluating the general performance of the AS test-group in the ToM battery in comparison to that of two control groups lead to the conclusion that the AS participants in the current study do not express notable ToM difficulties. These findings are not entirely surprising since ToM deficits are known to feature in some, but definitely not all those that were diagnosed with autistic spectrum disorders. The AS participants in the present study are defined as high-functioning, their verbal IQ is in the normal range and they are fairly communicative. Therefore, it only makes sense that they belong to the subgroup of autistic individuals that do not suffer from severe difficulties in ToM skills.

3.3. Working memory evaluation

Phonological working memory, the phonological loop, is a component of working memory that is specialized in maintaining verbal information (Baddeley and Hitch 1974). Proper retention of verbal information in short term memory is an imperative step in any process of language comprehension; however it has been shown that phonological working memory competence is most essential for repetition tasks, for the processing of long utterances that pose severe phonological-lexical load and for the processing of utterances that require phonological reactivation - repeated access to phonological information (Willis and Gathercole 2001, Friedmann and Gvion 2003, Gvion and Friedmann 2007, among others). In addition, it was suggested that working memory serves as a tool for integrating different types of information (O'Reilly et al. 1999). Since the process of extracting pragmatic inference relies heavily on the ability to tie together information from different sources (e.g. lexical, prosodic, world-knowledge), working memory is essential for inferential processing (O'Reilly et al. 1999, Bishop 2012b). Working memory enables operating on stored information and therefore it is one of the factors that support the utilization of contextual information in the process of language comprehension (Loukusa and Moilanenn 2009).

The participants in the present study completed four short-term memory tests from the *FriGvi working memory battery* (Friedmann and Gvion, 2003, Gvion and Friedmann, 2008) to evaluate whether they suffer loss in phonological working memory competence. The FriGvi battery is designed to measure working memory span and to assess phonological loop effects such as word length and lexicalization that feature in typical phonological working memory.

Three of the tests that were used in the present study assessed recall word span and one test measured recognition word span.

3.3.1. ***Recall word span:*** These tests are comprised of sequences of distinct words that were orally presented to the participants at rate of one word per second. The participants were requested to verbally recall each list of words they have heard. The recall tests include three different span tasks:

(14) Recall word span tests – task description

a. ***Basic word span***, in which the participants were asked to recall lists of semantically unrelated disyllabic words.
b. ***Long word span***, in which the participants were asked to recall lists of semantically unrelated four-syllable words.
c. ***Pseudo-word span,*** in which the participants were asked to recall lists of disyllabic non-words that were formed by replacing a single phoneme in different positions in actual Hebrew words (e.g. the non-word *paón* differ minimally from the Hebrew words *ʃaón* 'clock' or *maón* 'residence', by a single phoneme).

All three tests include six levels - the lowest level requires a recall of two-word lists and each consecutive level requires a recall of longer lists of words. The highest level in these tests requires a recall of six- or seven-word lists. Each level contains five lists of words for recall. Span is measured on a scale of 2 to 7 and is defined as the highest level in which at least three lists were fully and accurately recalled. An additional half point is given for achieving precise recalls for two out of the five lists in a given level (e.g. if a participant correctly recalls three lists of the lowest two-word level and only two lists of the three-word level, his span will be defined as 2.5). Low scores in the recall tests could imply a possible deficit in either the input or the output phonological buffer.

Table (15) presents one example for each of the recall span tests.

(15) Recall span tests – an example

Level	***Basic word span***	***Long word span***	***Pseudo-word span***
2 words	ʃaón, báyit	maaréxet, klemantína	paón, biké
	'clock, house'	*'system, clementine'*	---------
3 words	péca, ʃáar, kamút	mixnasáyim, maatafá, hitpaalút	léca, démeʃ, kaxót
	'wound, gate, quantity'	*'pants, envelope, admiring'*	---------
4 words	malón, nóar, sadé, tikrá	filosófya, magafáyim, mandarína, hictanenút	nolér, panád, záda, tasrá
	'hotel, youth, field, ceiling'	*'philosophy, boots, tangerine, a cold'*	---------
5 words	karít, nécax, makóm, safám, tevá	hitlaavút, diktatúra, nexiráyim, kerámika, agvaniyá	gécax, ʃabón, radíl, ʃéfal, tidá
	'pillow, eternity, place, mustache, box'	*'enthusiasm, dictatorship, nozzles, ceramics, tomato'*	---------
6 words	zakén, argáz, ribá, séder, maxvát, dóar	statístika, xaʃmelaút, astronómya, paamáyim, demagógya, plastelína	ráman, arláz, ribáf, vodér, maxʃét, dóxar
	'old, crate, jam, order, pan, post'	*'statistics, electrical engineering, astronomy, twice, demagogy, plasticine'*	---------
7 words	yatúʃ, sakín, narkís, gérev, meíl, masór, ʃezíf	---------	yasúʃ, sazín, narlís, gamáb, beíl, malór, ʃatíf
	'mosquito, knife, daffodil, sock, coat, saw, plum'	---------	---------

In addition to span capacity, input properties, such as word length and lexicality that typically affect phonological working memory, were also measured. Short words and real words are expected to be better maintained in phonological loop and therefore more easily recalled. In order to assess word length effects, the performance of the participants in the *basic word span* was compared with their span in the *long word* test. In order to evaluate lexical effects, *basic word span* and *pseudo-word span* tests were compared.

3.3.2. *Recognition word span:* Recognition tests are specifically designed to distinguish between deficits in input and output related operations of the phonological loop. These tasks rely exclusively on the retention of input, since they do not require any form of verbal production such as voiced recall or repetition.

(16) Recognition span test

Matching word order span in which the participants heard a pair of word lists that contained the same disyllabic words, and were asked to judge whether the words in this pair of lists were presented in the same order.

This task includes six levels, where the lowest level requires judgment of pairs of two-word lists and each consecutive level requires judging longer lists of words; the highest level in this test requires judging pairs of seven-word lists. Each level contains ten pairs of lists, five of which were matching pairs of lists and five were non-matching lists. Span was measured on a scale of 2 to 7 and was defined as the highest level in which at least seven pairs of lists was correctly judged.

Table (17) presents an example for the recognition word matching span test.

(17) Recognition word matching span test – an example

Level	***List 1***	***List 2***
2 words	ʃaón, báyit	ʃaón, báyit
	'clock, house'	*'clock, house'*
3 words	péca, morá, kamút	móra, péca, kamút
	'wound, teacher, quantity'	*'teacher, wound, quantity'*
4 words	nóar, panás, sadé, tikrá	nóar, panás, sadé, tikrá
	'youth, flashlight, field, ceiling'	*'youth, flashlight, field, ceiling'*
5 words	ʃirá, síax, galíl, ripúd, buá	síax, ʃirá, galíl, ripúd, buá
	'poetry, bush, roll, padding, bubble'	*'bush, poetry, roll, padding, bubble'*
6 words	bacál, zébra, svéder, kilkúl, safék, galím	bacál, zébra, svéder, kilkúl,, galím, safék
	'onion, zebra, sweater, breakdown, doubt, waves'	*'onion, zebra, sweater, breakdown, waves, doubt'*
7 words	yatúʃ, sakín, narkís, gérev, meíl, masór, ʃezíf	yatúʃ, sakín, gérev, narkís, meíl, masór, ʃezíf
	'mosquito, knife, daffodil, sock, coat, saw, plum'	*'mosquito, knife, sock, daffodil, coat, saw, plum'*

Participants who demonstrate low recall span and a normal recognition span could be described as suffering from a selective deficit in phonological output memory span whereas others, who achieve low scores in both types of tests, recall and recognition,

express a difficulty in input phonological memory span as well as a possible deficit with output.

3.4. Working memory evaluation – results

The results of the working memory evaluation indicate that most of the participants did not significantly differ in their performance from their age matched controls and did not demonstrate response pattern that could be consider as reflecting a systematic failure of phonological working memory abilities.

Table (18) presents the scores of the AS participants compared with those of age matched control group (age group of 20-40) from Gvion and Friedmann, 2008.

(18) Working memory evaluation – FriGvi

Task / Participant	Recall			Recognition
	Basic word span Max score 7	**Long word span** Max score 6	**Pseudo-word span** Max score 7	**Matching word order span** Max score 7
1	5	3.5	3	7
2	5	4	3	4*
3	5	4.5	3	6
4	4*	3*	2*	3*
5	4.5	3.5	3	4*
6	5	4	3	7
7	5	4	3	4*
8	4*	2.5*	2*	3*
9	4.5	4	3	5
10	6	5	5	6
Average score of AS group (SD)	**4.9** (0.5)	**3.9** (0.6)	**3.1** (0.7)	**5.0** (1.4)
Average score of age-matched control (SD)	**5.4** (0.7)	**4.6** (0.6)	**3.3** (0.5)	**6.4** (1.0)

* $p < 0.05$

Three participants (2, 5 and 7) scored significantly lower than age-matched control group on the matching word order span, which is a binary yes/no judgment task. However, these participants scores were within the low range of the normative score

in all other working memory tests that required active recall of verbal information, therefore in general, these participants did not present performance pattern that reflect phonological short-term memory deficiency.

Participants 4 and 8 scored significantly lower than the age-matched control group in all four tests and therefore could be defined as suffering from an impaired phonological working memory. It should also be noted that within the AS test-group, these two participants achieved the lowest verbal-IQ scores (87 and 80 respectively).

Bishop (2012b) found that participants with lower working memory capacity experienced greater difficulty than their peers in tasks requiring integration of varied, and sometimes infelicitous, prosodic stimuli, with previous context. Bishop surmises that this type of tasks poses greater burden on attentional resources.

Based on these findings, it could be predicted that participants 4 and 8 might demonstrate greater difficulties than their AS test-group peers in some of the prosodic tasks. However, it is not expected that phonological working memory abilities will interfere or affect the performance of the rest of the AS test-group in the PROSA battery.

3.5. Language skills evaluation

This section of the experiment includes tests that probe various linguistic abilities, which were selected based on three inclusion measures.

The first measure refers to linguistic skills that are necessary for basic comprehension of study's tasks. The vast majority of the PROSA battery's tasks comprised of auditory stimuli in the form of single words or simple sentences; however, several tasks, including those of the aTOMic battery, require reading abilities and comprehension of complex sentences that contained embedded clauses and syntactic movement. Therefore, the language skill evaluation included a battery of three reading tasks for identifying subtypes of dyslexia in Hebrew (Friedmann and Gvion 2003) and a picture-matching task that evaluated comprehension of complex sentences that contained syntactic movement in relative clauses and in Wh-questions (Friedmann 1998, Friedmann and Novogrodzky 2002).

The second measure refers to syntactic and lexical abilities that were shown to be impaired in various populations with language disabilities and therefore could serve as indicators for linguistic impairments. This type of abilities includes lexical retrieval and the ability to repeat and produce complex sentences with various types

of syntactic movements and embedding (Biran and Friedmann 2004, 2005, Friedmann et al. 2013, Friedmann 1998, 2000, Friedmann and Szterman 2006, Novogrodsky and Friedmann, 2006).

The last measure refers to linguistic abilities that were predicted to affect prosodic competence or to be affected by a prosodic deficiency. Former studies of prosody in autism tend to connect prosodic deficit with pragmatic deficiencies, therefore, two novel tasks that aimed to evaluate several aspects of pragmatic ability were incorporated in this section of linguistic skills evaluation.

The following sections present task descriptions and results of the syntactic tests (§4.5.1), lexical test (§4.5.2), reading tests (§4.5.3) and pragmatic tests (§4.5.4) that were used in order to measure the participants' language skills. Evaluating the participants' competence in this wide range of tasks allows investigation of possible correlations between different aspects of impaired language, and enables a comparison between the AS test group and other populations that are characterized with language disabilities.

3.5.1. ***Language skills evaluation: Syntactic competence:*** The participants completed three syntactic tasks that involved comprehension, repetition, and production of complex syntactic structures. These tasks are comprised of various structures that were found to be difficult for individuals with different language impairments (Bishop et al. 2000, Bishop 2006, Friedmann and Novogrodsky 2008, 2011, Friedmann and Szterman 2006). Since it was established that these structures are typically mastered by Hebrew-speaking children with normal language acquisition around the age of 6 (Friedmann and Lavi, 2006; Friedmann and Szterman, 2006), some of the comparison groups for these tasks were much younger than the test group.

3.5.1.1. ***ZST-TLT - Comprehension of relative clauses and Wh-questions (picture matching task):*** Comprehension of structures that contain Wh-movement, i.e. relative clauses and Wh-questions, was assessed using sentence-picture matching task

Procedure: The test contains 20 pictures and 80 sentences; each picture displays three characters and was presented four times throughout the test to match four different sentences. The sentences in this test comprise of 20 subject relative sentences, 20 object relative sentences, 20 subject Wh-questions (which-subject), and 20 object Wh-questions (which-object). The sentences were presented in a random-like order. The participants heard a sentence and were asked to point to one character, to which the sentence was referring. In each picture two analogous characters were employed as the subject and the object of an action. An example of a picture that was used in this test is given in (20) following the four relevant sentences which applied to this picture (in 19a-d).

(19) Comprehension of relative clauses and Wh-questions – target sentences

	Sentence type	***Sentence***
a.	Subject relative	Show me the giraffe that is measuring the girl.
b.	Object relative	Show me the giraffe that the girl is measuring.
c.	Subject Wh-question	Which giraffe is measuring the girl?
d.	Object Wh-question	Which giraffe is the girl measuring?

(20) Comprehension of relative clauses and Wh-questions – an example of a picture for the sentences in (19)

Results: The results of the AS test-group were compared with a control group of 14 fourth-grade pupils (Friedmann and Szterman 2006). None of the AS participants significantly differ from the control group.

(21) Comprehension of relative clauses and Wh-question (ZST-TLAT)

Sentence type / **Participant**	**Subject relative** Correct response out of 20 items	**Object relative** Correct response out of 20 items	**Subject Wh-question** Correct response out of 20 items	**Object Wh-question** Correct response out of 20 items
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20
5	19	20	20	19
6	19	18	20	19
7	20	19	20	20
8	20	20	20	20
9	20	20	20	20
10	20	20	20	20
Average score of AS group (SD)	**19.8** (0.4)	**19.7** (0.6)	**20.0** (0.0)	**19.8** (0.4)
Average score of control (SD)	**19.7** (0.5)	**18.7** (1.5)	**20.0** (0.0)	**19.8** (0.4)

The participants' performance in the comprehension task did not reveal significant difficulties in their ability to comprehend Wh-movement in general and right-branching objects relatives and object questions in particular. These structures are known to be the source of great difficulties for individuals with syntactic disabilities (Novogrodsky and Friedmann 2006, Fattal et al. 2011).

3.5.1.2. *PETEL - Syntactic movement - repetition task*

The procedure of sentence repetition cannot be considered as merely technical imitation of the target utterance, rather, it relies on syntactic competence and involves both comprehension and production processes. Therefore, difficulties that emerge in

repetition tasks can serve as sensitive markers for deficits in the ability to comprehend and produce specific syntactic structures (Lust et al. 1996, Friedmann 2007, Fattal et al. 2011).

Procedure: The syntactic structures in this task include sentences with various types of syntactic movements: Wh-movement (with and without embedding), verb movement (V2) to second position in the clause (immediately following the initial constituent), and A-movement (from object position to subject position in sentences that contain unaccusative verb). The task includes other complex structures such as sentences with embedded clauses, as well as simple sentences without movement and without embedding that were used as control (see (22) below).

The test includes 70 sentences, each comprising of four words. The experimenter read each sentence aloud and the participants were asked to wait three seconds and repeat the sentence as accurately as possible.

The results of the AS test group were compared with the *PETEL* control data of 17 children (mean age 13;0, SD=2;9).

Results: The results of the repetition task reveal that the AS performance as a group did not fall short of that of the control group.

(22) Syntactic movement repetition task – results

Sentence type	Source of syntactic difficulty	Number of items	Example	AS accuracy rate % (SD)	Control accuracy rate % (SD)	AS participants below the control
Object relative	Wh-movement and embedding	10	**zo ha-talmida ʃe-ha-mora xipsa** this the-pupil(fem.) that-the-teacher(fem.) looked-for *'This is the pupil the teacher looked for'*	94 (8.2)	92 (9.4)	Participant 8 (2 structural errors)
Topicalization	Wh-movement	10	**et ha-mora ha-zo ha-talmida xipsa** ACC the-teacher(fem.) DET-this the-pupil(fem.) looked-for *'This is the teacher the pupil looked for'*	98 (6.3)	96 (6.0)	
Object question	Wh-movement	5	**et eize mora ha-yalda ohevet?** ACC Which teacher(fem.) the-girl loves? *'Which teacher the girl loves?'*	80 (22.0)	98 (6.4)	Participants 4 & 8 (2 & 3 errors respectively)
Subject question	(canonical) Wh-movement	5	**eize saxkanit raata et ha-mora?** Which actress saw ACC the-teacher(fem.)? *'Which actress saw the-teacher?'*	100 (0.0)	98 (6.4)	---
Verb movement (VSO)	Verb movement	10	**etmol biker ha-yeled xaver** Yesterday visited the-boy a friend(masc.) *'Yesterday the boy visited a friend'*	97 (4.7)	96 (5.9)	---
Unaccusative	A-movement	10	**etmol ha-kadur hitgalgel ba-gina** Yesterday the-ball rolled in-the-garden *'Yesterday the ball rolled in the garden'*	97 (4.7)	99 (2.1)	---
Embedded sentential complement	Embedding	10	**aba amar ʃe-ima yeʃena** Dad said that-mom sleeps *'Dad said that mom sleeps'*	99 (3.1)	98 (5.1)	---
Simple	None	10	**etmol ha-yeled pagaʃ et ha-ʃaxen** Yesterday the-boy met ACC the-neighbor(masc.) *'Yesterday the boy met the neighbor'*	100 (0.0)	99 (2.4)	---

Two participants, 8 and 4, differed from control (Crawford-Howell t-test, $p < 0.05$) and showed some difficulty in repeating two types of non-canonical sentences derived by Wh-movement (A-bar movement). Participant 8 made two lexical errors in object relative sentences and three structural errors in object question sentences. Participant 4 made two structural errors in object relative sentences. ***Lexical errors*** are errors in which a constituent of the target sentence is replaced by another constituent of the same syntactic category (e.g. replacing the constituent ha-talmida *'the pupil'* with another noun when repeating the following sentence: "zo ha-talmida ʃe-ha-mora xipsa" *'This is the pupil the teacher looked for'*). ***Structural errors*** are errors that alter the sentence's syntactic structure and theta grid (e.g. repeating the sentence "zo ha-talmida ʃe-ha-mora xipsa" *'This is the pupil the teacher looked for'* as "ha-talmida xipsa et ha-mora" *'the pupil looked for the teacher'*.

3.5.1.3. *ZIBUV - Elicitation of relative clauses - picture description task*[12]

This test examines the participants' ability to produce object and subject relative clauses; structures that derive from syntactic movement.

Previous findings indicate that many individuals who suffer from a syntactic impairment demonstrate difficulties in the production of relative clauses, and of object relatives in particular. It was suggested that these difficulties stem form a deficit in the assignment of thematic roles to moved constituents (Novogrodsky and Friedmann 2006). It was reported that children with syntactic-SLI as well as autistic children often avoid the production of target relative sentences in elicitation tasks, and that their productions are in many cases ungrammatical or pragmatically inappropriate for the elicitation context (Novogrodsky and Friedmann 2006). In Friedmann et al. (2015) it was reported that the performance of 93% of the children with syntactic SLI that participated in their research (163 out of 175 children, mean age=11;2, SD=2;3) was significantly poorer than that of the control group in the relative clauses elicitation task. In Yosef-Sukenik (2012) 10 out 18 autistic children (age: 8-17) were significantly poorer than the control group in producing subject relatives, and 11 out of the 18 participants showed impairment in their ability to produce object relatives.

[12] It should be mentioned that the picture description task for the elicitation of relative clauses was chosen over the preference elicitation task (*ADIF*, Friedmann and Szterman 2006, Novogrodsky and Friedmann 2006) since the latter rely, to some extent, on ToM abilities. In the preference elicitation task, the experimenter describes two characters in two situations and the participants are asked to choose which character they prefer to be. This task requires the participants to identify with the characters.

Procedure: The participants were presented with a pair of pictures; each pair illustrated two characters (see (23)). One of the pictures in each pair displayed a character which was performing an action that applied to the other character (a boy hugging a monkey, in (23a)). The second picture in the pair displayed the reversed occurrence of that action (a monkey hugging a boy, in (23b)).

(23) Relative clause elicitation task - images

a. 

b. 

The participants heard a description of the two pictures (24) followed by a question, which aimed to elicit target sentence that required the production of either a subject relative clause (25a) or an object relative clause (25b).

(24) *'There are two boys in these pictures, in one picture the boy is hugging the monkey, and in the other picture the monkey is hugging the boy. Which boy is this?* (pointing at the boy in (23a)) *Start your answer with 'This is the boy…'. And now, which boy is this?* (pointing at the boy in the other picture (23b))*'*

(25) Target response

a. *Subject relative*

ze ha-yeled ʃe-mexabek et ha-kof

this the-boy that-hugs ACC the-monkey

'This is the boy that hugs the monkey'

b. *Object relative*

ze ha-yeled ʃe-ha-kof mexabek

this the-boy that-the-monkey hugs

'This is the boy that the monkey hugs'

This test was comprised of ten pairs of pictures and 20 elicitation questions. Ten of the questions aimed to elicit subject relative clauses and the other ten aimed to elicit object relative clauses.

Results:

As evident from table (26), most of the AS participants were able to produce both subject- and object - relative target sentences in response to elicitation. The performance of the AS group was compared with a control group of 15 fourth-grade pupils (taken from Yosef-Sukenik 2012). However, three participants demonstrated response pattern that differed from control in the object relative condition. The results of these participants were analyzed separately and are presented in (27).

(26) Elicitation of relative clauses - picture description task (ZIBUV)

Target sentence / **Participant**	**Object relative** **Accuracy rate (%)** (10 items)	**Subject relative** **Accuracy rate (%)** (10 items)
2	100	100
3	100	100
4	100	100
6	90	100
7	100	100
9	100	100
10	90	100
Average accuracy rate of AS group (SD)	**98.6** (3.5)	**100.0** (0.0)
Average accuracy rate of control (SD)	**95.0** (9.0)	**99.0** (3.0)

Participant 1 systematically produced full passive subject relatives in 8 out of 10 object-relative elicitation contexts (see (27c) for an example). His productions were grammatical, and pragmatically felicitous. The other two productions of participant 1 were the expected target object relative sentence. Novogrodsky and Friedmann (2006) specify that full passive constructions are used by children with syntactic-SLI in order

to escape the production of object relatives. However, passives are just one of various strategies used for avoiding movement from object position. Some of the other examples for non-target productions include simple sentences, object relatives with an arbitrary subject, reflexivization and other predicate alterations and subject relatives with head doubling. The systematic pattern of participant 1 response in the present elicitation task, together with the fact that this participant did not exhibit difficulties in any other syntactic task could imply for a use of strategy and not necessarily indicate a problem.

The other two participants that differ from control in this task were participants 5 and 8, who showed response pattern that resembles that of the syntactic-impaired children reported in Novogrodsky and Friedmann's (2006) study. These participants used several tactics to avoid the production of object relatives and some of their productions were ungrammatical or pragmatically infelicitous. The response analysis of these participants is detailed in (27).

(27) Object relative elicitation response analysis – participants 1, 5 and 8

Response type	Example	1 10 items	5 10 items	8 10 items
(a) **Object relative** (target)	**zo ha-yalda ʃe-ha-savta menaʃeket** This the-girl that-the-grandmother kisses *'This is the girl that the grandmother kisses'*	2/10	1/10	4/10
(b) **Object relative with an arbitrary subject** (Target: This is the boy that the grandfather drags)	**ze ha-yeled ʃe-gorerim oto** this the-boy that- drags -pl. him *'this is the boy that (someone) drags'*	0/10	0/10	1/10
(c) **Subject relative with full passive** (Target: This is the boy that the dog pets)	**ze ha-yeled ʃe-melutaf al-yedey ha-kelev** this the-boy that-petted by the-boy *'This is the boy that is petted by the dog'*	8/10	4/10	0/10
(d) **Subject relative with a verb change** (Target: This is the boy that the mother hugs)	**ze ha-yeled ʃe-mekabel xibuk** this the-boy that-receives hug *'This is the boy that receives a hug'*	0/10	4/10	2/10
(e) **Subject relative with a reflexive verb** (Target: this is the boy that the king combs)	**ze ha-yeled ʃe-mistarek** This the-boy that-combs-refl. *'This is the girl that combs herself'*	0/10	0/10	1/10
(f) **Doubling of the relative head** (Target: this is the girl that the grandmother pinches)	***zo ha-yalda ʃe-ha-savta covetet et ha-yalda** this the-girl that-the-grandmother pinches the-girl **'This is the girl that the grandmother pinches the girl'*	0/10	1/10	0/10
(g) **Theta roles incongruent with predicate** (Target: this is the boy that the monkey *hugs')*	***ze ha-yeled ʃe-mitxabek ecel ha-kof** This the-boy that-hugs-reciprocal at the-monkey **'This is the boy that hugs-reciprocal with the monkey'*	0/10	0/10	1/10
(h) **Simple sentence** (Target: this is the girl that the grandmother kisses)	**#zo ha-yalda ʃe-ha-savta menaʃeket et... ha-savta menaʃeket et ha-yalda** This the-girl that-the-grandmother kisses the… the-grandmother kisses the-girl This is the girl that the grandmother kisses the… The grandmother kisses the girl	0/10	0/10	1/10

It should be noted that in terms of pragmatic felicity and grammaticality, the description given in sentences (27b-e) appropriately capture the state of affairs illustrated in the relevant picture stimuli. However, the diversity of avoidance strategies and the occurrences of ungrammatical productions suggest that these participants suffer from some difficulty in syntactic operations that involves A-bar movement from object position.

3.5.2. *Language skills evaluation: Lexical retrieval*

Lexical retrieval is a complex multi-staged process that involves distinct conceptual, semantic, phonological and syntactic components. Deficits in lexical retrieval abilities (i.e. anomia) feature in individuals with various developmental and acquired language impairments. A failure of the lexical retrieval operation could emerge due to deficits in different components of the retrieval model or due to impairments in the connections between these components. Impairments of different components are characterized by distinct retrieval failures. Mapping of these failures enables identification of different sub-types of anomia.

Procedure:

The ***SHEMESH lexical retrieval naming task*** (Biran and Friedmann 2004, 2005) includes 100 colored object pictures. The participants were asked to name the pictures that were presented individually. Picture naming task is commonly used for the examination of lexical abilities since it involves all stages of word production (from conceptual level to pronunciation). Error type analysis enables examination of the specific loci of the retrieval deficit (Levelt et al., 1998, Biran and Friedmann 2005, Friedman et al. 2013).

Results:

Table (28) presents the AS participants' results in the lexical retrieval task, compared with a group of 126 control participants (mean age of 33;4) from Biran and Friedmann (2004).

(28) SHEMESH – lexical retrieval naming task: results

Participant	**Accuracy rate (%)**
1	96
2	99
3	98
4	92*
5	92*
6	98
7	98
8	100
9	99
10	98
Average accuracy rate of AS group (SD)	**97.1** (2.8)
Average accuracy rate of control group (SD)	**98.3** (1.9)

* $p < 0.005$

Two participants (4 and 5) scored significantly lower than the control group in this task. Both participants made 8 naming errors. An analysis of their errors according to target-word's features (e.g. semantic category, grammatical gender, target-word length) and according to error type (semantic/phonological similarity to target) indicate that semantic errors were the most frequent type of naming errors and that most of the incorrect responses were close alternatives of the target-words in terms of semantic category (e.g. orange-lemon, sword-knife, sock-boot).

3.5.3. *Language skills evaluation: reading*

The vast majority of the PROSA battery tasks comprises of auditory stimuli and does not rely in any way on reading skills. However, in order to neutralize the prosodic variable and prevent its possible influence on other cognitive and linguistic abilities that were evaluated in this study, several tasks (such as those of the aTOMic battery) were deliberately designed as reading tasks. An examination of the participants reading abilities was therefore an essential step in order to define their linguistic skills and verify their ability to meet practical requirements of the study's tasks.

Procedure:

The ***TILTAN Battery for identifying subtypes of dyslexia*** (Friedmann and Gvion 2003) was used in order to evaluate the AS participants reading skills. The screening part of the battery includes three lists of words: (a) 136 single-word list (b) 30 pseudo-word list, and (c) 30 word-pairs. These lists are comprised of various types of words that are prone to evoke characteristic errors amongst individuals that experience reading disabilities. Words and pseudo-words that could be read as an alternative entry due to migration of letters within the word are used for identifying letter position dyslexia (e.g. target word: תריס tris *'shutter',* potential output: תירס tiras *'corn'*). Homophones and irregular words are used for detecting surface dyslexia (e.g. target word צאן čon *'sheep'*, potential output: čaan *(non-word)*). Words and pseudo-words that could be altered to different words as a result of neglecting the edge of the word serve as indexes for neglect dyslexia (e.g. target word: ראשון riʃon *'first'*, potential output: ראש roʃ *'head'*), and function words, abstract words and morphologically complex words are used for detecting deep dyslexia (e.g. מרכזיות merkaziot *'central fm. pl.'*). In order to identify attentional dyslexia, word pairs are form such that letter migration between words could result in other existing words (Friedmann et al. 2010).

The participants were requested to read the words aloud. Their performance was recorded and analyzed based on error type.

Results:

The performance of the AS participants was compared with that of 372 control participants (Friedmann and Gvion 2003).

(29) TILTAN battery for identifying subtypes of dyslexia: reading tasks - results

Sentence type / Participant	**Single word list** (136 words) **% accuracy**	**Pseudo-word list** (20 words) **% accuracy**	**Word pairs** (20 pairs) **% accuracy**
1	100	100	100
2	100	100	100
3	99.2	100	95.0
4	100	95.0	90.0
5	97.7	90.0	85.0
6	100	90.0	90.0
7	98.5	100	85.0
8	89.4*	75.0*	85.0
9	100	100	100
10	100	100	90.0
Average accuracy rate of AS group (SD)	**98.5** (3.1)	**95.5** (7.9)	**92.0** (6.0)
Average accuracy rate of control (SD)	**98.4** (1.9)	**93.9** (1.3)	**92.1** (1.4)

* $p < 0.005$

With the exception of participant 8, all the AS test-group participants showed intact reading abilities. The error analysis of participant's 8 performance reveals error pattern that are compatible with two types of dyslexia: (a) surface dyslexia - a reading deficit in the lexical route that result in regular reading via grapheme-to-phoneme conversion mechanism (Friedmann and Lukov 2008), and (b) attentional dyslexia - a deficit in letter-to-word binding, in which letters migrate between neighboring words (Friedmann et al. 2010).

3.5.4. *Language skills evaluation: Pragmatic ability*

Traditional views hold that pragmatic difficulties form one of the salient disabling features of autism spectrum disorders (e.g. Landa 2000, Ozonoff and Miller 1996, Ramberg et al. 1996, Loukusa and Moilanen 2009). It was argued that AS individuals find it hard to rely on social context and non-literal information as a basis for understanding the underlying massage of an utterance and that non-literal language is often misinterpreted (Gillberg 2002). However, empirical evidence for pragmatic malperformance of the AS population is inconsistent. While some studies found significant differences in non-literal language comprehension (e.g. Happé 1993, Martin and McDonald 2004), others report that individuals with AS do not underperform non-literal language comprehension tasks and contextual processing tasks (e.g. Norbury 2005, Pijnacker et al. 2009, Giora et al. 2012, Abramson 2012). It should be noted that most of the participants in the present study (with the exception of participants 2, 5 and 8) took part in Abramson's (2012) experimental study of irony comprehension and were found to be no different than typically developed control participants in their ability to detect and interpret ironic statements in written texts.

These inconclusive findings cast doubt on the assumption that impaired pragmatic abilities manifested as a universal feature of the autistic population.

In the field of prosody in autism, former research, though inconsistent to some extent, suggest that prosodic difficulties are prone to appear when prosody serves pragmatic functions while grammatical uses of prosody are predicted to remain intact (Kujala et al. 2005, Chevalier et al. 2009, Shriberg et al. 2001, Paul et al. 2005 among others).

Therefore, the general linguistic skills evaluation included two pragmatic tasks. One that required bridging textual gaps using inferences (text-connecting and gap-filling) and the other involved the operation of generating scalar implicatures.

3.5.4.1. *Textual gaps – story comprehension task*

Definitions of pragmatic processes in the literature tend to vary according to theoretical framework and study's objectives. However, regardless of these differences, the general consensus is that utilization of context as a tool for inferring non-literal content is a pragmatic skill. The same utterance might express different meanings in various communicative states. Exploiting the relevant context is, therefore, a necessary step in order to achieve comprehensive interpretation of

speaker's intention and adequate understanding of utterance meaning (Sperber and Wilson 1986/1995, Wilson and Sperber 1988, Loukusa and Moilanen 2009).

Procedure:

The participants were presented with four short paragraphs describing a sequence of events (see an example in (30) below). The connection between the events was implied but not literally stated in the text. The participants were then asked to fill two types of textual lacuna: one type regarded physical course of events and the other type involved the protagonists' knowledge and mental state (31) by answering a list of 4 to 6 questions (a total of 19 questions). Bridging these textual gaps requires excessive utilization of context and construction of meaning by inference.

(30) Textual gaps - story comprehension task

Ruth has an exam on Friday. On Thursday, the night before her exam, her close friend Greg is throwing a birthday party.

Ruth told Greg that she will study hard all week in order to finish her studying as early as possible.

On Thursday eve Ruth did not feel well.

On Friday morning, when Ruth arrived to school, she met Greg. He came to her and said - 'Well, I see that eventually you did not study hard all week!'

(31) Questions regarding non-literal information in the text:

a. Has Ruth intended to arrive to Greg's party?
   Expected answer: *yes.*
b. Has Ruth studied hard all week?
   Expected answer: *yes.*
c. Has Ruth arrived to Greg's party?
   Expected answer: *no.*
d. Has Ruth taken her exam on Friday?
   Expected answer: *yes.*
e. Did Greg know that Ruth did not feel well on Thursday?
   Expected answer: *no.*

f. Why did Greg say those things to Ruth?

Expected answer: *Because he was not aware that she was in fact studying hard all week and that the reason for her absence was that she felt ill at the night of his party.*

None of the answers to the above queries was explicitly stated in the text; however, it was implied by the course of events. Some of the relevant implicatures could be derived based on context alone (31b-d) while others required the integration of contextual implicatures with an interpretation regarding the protagonists' intentions and knowledge (31a and 31e-f).

Results:

The performance of the AS group was compared with that of 13 control participants (Mean age = 26.2, SD = 4.4). Each answer was scored 1 for correct response and 0 for incorrect response. The vast majority of gap filling questions received the expected answers by both groups' participants.

(32) Textual gaps - results

AS test-group (n=10)	***Control group (n=13)***
% correct response (SD)	*% correct response (SD)*
95.6 (6.5)	**95.9** (5.2)
180/190	235/247

No differences were found between the groups and no individual participant in the AS test group scored significantly lower than control. However, the performance of two AS participants, 8 and 4 (verbal IQ 80 and 87 respectively), was relatively poorer than that of the other members of the AS group (87.5% and 85.4% of accurate responses). These results are compatible with Norbury's (2005) claim that formal verbal abilities, rather than ToM skills, plays greater role in the comprehension of non-literal language among clinical and typical populations. Her findings indicate that high functioning autistic children, who scored within the normal range on structural language tasks, did not differ from their control peers in the use of context to resolve lexical ambiguities (for similar correlation see also Snowling and Frith 1986). These findings emphasize the need to consider formal linguistic skills, and control for syntactic and lexical abilities in the evaluation of pragmatic competence (Bishop and Norbury 2005).

3.5.4.2. *Generating Scalar Implicatures*

The meaning of an utterance depends not only on its explicit literal content, but also on pragmatic inferences that evoke certain implicit meanings. These inferences are in many cases triggered by linguistic expressions (see (33)); however, pragmatic inferences could also be triggered by prosodic cues, as in the case of implicatures that are induced by focal accent. Therefore, in order to identify possible relations between prosodic difficulties and pragmatic deficits, it was essential to evaluate the mere ability of the AS participants to derive pragmatic inferences that are not prosodically triggered. One type of such inference is *Scalar Implicatures* that are triggered by the scalar expression '*some'*.

It is generally accepted that certain linguistic expressions are associated with scales of informativeness, i.e. Horn Scales (Horn 1972).[13] The standard theory of *Scalar Implicatures* incorporate *scales* as a mechanism that defines and constraints the formation of alternative meanings for scalar items. These items are assumed to make salient a formal set of ordered alternatives; e.g., the scalar expression *'some'* is associated with the following set of alternatives.

(33) <some << many << most << all>.

According to Grice (1975), natural conversation is driven by a cooperative principle according to which speakers are expected to follow certain conversational maxims. Implicatures that are introduced by scalar expressions could be explained as stemming from the maxim of quantity.

(34) Maxim of quantity: *Use the stronger statement, within a set of candidates*.

According to this maxim, the use of a weaker statement from a scale of statements that are ordered in terms of semantic strength implies that to the best of the speaker's knowledge, none of the stronger statements in the scale is applicable in the given context. Hence, the use of a weaker term by the speaker directs the hearer to assume that the speaker had reasons not to use a stronger, more informative, term.

[13] See Fox and Katzir (2011) for a different view of the computation mechanisms of formal alternative sets for *Scalar Implicatures*.

Procedure:

Scalar Implicature stimuli were used in a picture matching task in which the participants listened to an auditory stimulus of a sentence and were asked to decide which picture out of three optional pictures that appeared on the screen was most compatible with the sentence.

It should be mentioned that the *Scalar Implicature* stimuli that are described in this section cover only one subtype of the full array of sentences that were used in this pragmatic picture-matching task. The full task is detailed in section 6.3.1.

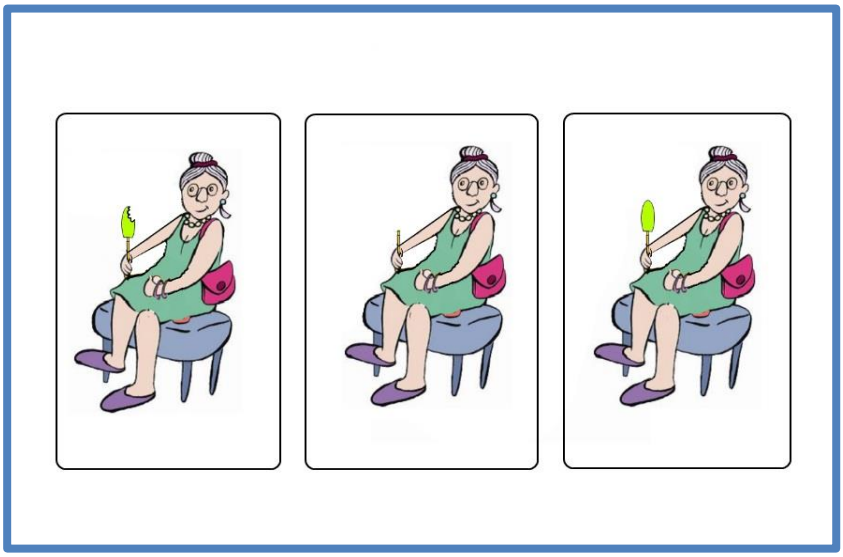
The *Scalar Implicature* stimuli included 7 sentences with the expression *xelek 'some'* (35a). These sentences were uttered in a neutral intonation.

(35) Scalar implicatures

a. ha-savta axla <u>xelek</u> me-ha-kartiv

'The grandmother ate <u>some</u> of the Popsicle'

b. Screen image for (35a):



Both the left and the middle pictures in (35b) represent cases that are logically compatible with an event in which the grandmother ate *some* of the popsicle (eating *all* entails eating *some*). However, assuming a cooperative speaker that follows the Gricean conversational maxim of quantity, the expected decision for most suitable picture should be the left picture, based on the understanding that if the speaker chose to use the expression *xelex 'some'* in his utterance, stronger statements such as *'The grandmother ate <u>all</u> of the Popsicle'* should be rejected. The added meaning of *not all*

is not a part of the literal content of (35a) but an implicature that arise from conversational principles (Grice 1975, Horn 1972).

Results:

As evident from (36) below, the performance in this task did not differ across groups and was at ceiling for both groups.

(36) Scalar implicatures - results

AS test-group (n=10)	***Control group (n=25)***
% correct response	*% correct response*
100 (70/70)	**100** (175/175)

These results support Pijnacker et al.'s (2009) findings. In their reading task, underinformative sentences, such as *'Some sparrows are birds'*, were judged as *True* or *False* by a group of high functioning autistics and individuals with AS. This type of sentences is logically true but pragmatically inappropriate due to the implicated negation of the stronger statement that derives the following *'Not all sparrows are birds'* implicature. According to Pijnacker et al.'s (2009) results, the AS participants exhibited control-like performance and did not differ in their ability to produce pragmatic enrichments and derive *Scalar Implicatures*.

The participants' control-like performance in the present task, though based on a relatively small sample of sentences, might add to Pijnacker et al.'s findings the facet of generating *Scalar Implicatures* in spoken language comprehension, a process that potentially poses additional challenges such as the need to elaborate auditory information and produce online inferences.

3.6. Evaluating linguistic and cognitive abilities – Summary

As other autistic disorders, Asperger syndrome is characterized by qualitative impairments in social communication. However, it was claimed that in contrast to other syndromes of the autism spectrum, AS is not coupled with atypical language development. The communicative difficulties of AS population were explained in the literature, therefore, as stemming from pragmatic impairments and ToM deficiencies, while formal linguistic skills were predicted to remain generally intact. The results of some recent studies cast doubt on this dichotomy showing that not all pragmatic abilities are defected in AS, and that some of the AS population demonstrate deficiencies in

formal language skills (McCann et al. 2007, Norbury 2005). The results of the present evaluation strengthen this view.

The following table (37) summarizes the results of the participants' linguistic and cognitive evaluation that included the assessment of ToM abilities, working memory, syntactic skills, lexical retrieval, reading and pragmatic competence.

As a group the AS test-group did not differ from control in any of the evaluated tasks.

(37) Linguistic and cognitive evaluation - Summary

Task / Participant	ToM	Working memory				Syntactic			Lexical retrieval	Word reading			Pragmatic	
		Basic word span	Long word span	Pseudo-word span	Match.	Comp.	Rep.	Elic.		Single word	Pseudo-word	pairs	Scalar impl.	Textual gaps
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														

Significant difference: $p<0.05$

Match. = Matching word order span, Comp. = comprehension, Rep. = repetition, Elic. = elicitation, impl. = implicatures

Three participants, 4, 5 and 8, were the only individuals in the AS test group who exhibited difficulties in more than one evaluation task. Participant 4 scored lower than control in all four working memory tasks. In addition, he showed some difficulty in the syntactic tasks (significant difference was found only for the repetition task) and in lexical retrieval task. Participant 5 showed local difficulty in the working memory matching task and was not defined as suffering from working memory deficiency. He showed great difficulty in the syntactic elicitation task, however he did not underperform the syntactic repetition and the comprehension tasks. Additionally, he differed from control in lexical retrieval task. Participant 8 showed significant difficulties in the largest number of tasks. He differed from control in working memory, syntactic and reading tasks.

Various reports indicate that within the heterogeneous group of individuals that suffer from language impairment, subgroups can be identified according to the defected language component (Bishop et al. 2000, Bishop 2006, Friedmann and Novogrodsky 2008, 2011). Friedmann and Novogrodsky (2008) specifically refer to several identifiable subtypes of SLI (specific language impairment) in children. Their findings reveal a possible dissociation between syntactic, lexical and phonological deficits. According to their report children with pure syntactic-SLI were impaired in their ability to comprehend and produce complex syntax while showing good lexical retrieval skills and intact phonological skills. The deficit of the lexical-SLI group was related to the retrieval of words. This group showed intact syntactic and phonological abilities (see also Dockrell and Messer 2007). The phonological-SLI group's deficit was limited to their ability to segment words and repeat pseudo-words; however, their performance in the syntactic and lexical tasks was no different than that of control.

In the present study, the AS test-group did not show systematic failure of linguistic abilities, although participants 4, 5 and 8 did differ from control in several tasks. Due to the attained dissociation between different types of language impairments (Friedmann and Novogrodsky 2008), the observed difficulties of these three participants might not directly affect their prosodic abilities; however, the possibility that prosodic tasks which involve long sentences or complex syntax will pose greater challenge for this subgroup of AS participants, should be taken under consideration.

4. The design of the PROSA battery - Prosody evaluation

The *Receptive Prosody battery (PROSA)* that I have developed specifically for the present study, is comprised of 16 novel prosodic tests, aimed to evaluate the participants' ability to use prosodic cues in language comprehension. Furthermore, in order to address some of the predictions made in the literature regarding the pragmatic nature of the autistic deficit, the battery was designed to trace variations in the participants' prosodic competence when prosody serves different functions in speech - grammatical functions, pragmatic functions and affective functions.

Each prosodic function was tested in both discrimination and comprehension tasks in order to assess different levels of prosodic competence. Discrimination tasks aimed to test whether the participants are able to recognize different prosodic patterns and distinguish between forms that differ only in their prosody. Comprehension tasks aimed to test whether the participants are able to use prosodic information in order to give meaningful interpretation to utterances in which prosody has a direct effect on implications or on basic meaning. The tests consisted of both word-level and sentence-level stimuli.

For a review of the PROSA battery's general design, see §4.3 below. Task descriptions and group results of the discrimination and comprehension sections of the PROSA battery are presented in sections §5 and §6 respectively and reaction time analysis is presented in section §7. Section §8 considers further issues regarding group analysis and discusses individual performance of the AS participants in the PROSA battery.

4.1. Stimuli

In order to ensure high quality audio stimuli and to allow accurate analysis of phonetic measurements of prosodic correlates such as pitch, loudness (intensity) and duration, the recordings were made in a quiet room using professional recording equipment. The position of the speaker's head, relative to the microphone, remained fixed, thus allowing a relatively stable and reliable recording of intensity changes. A condenser microphone was linked up to a computer with a professional Audio interface equipped with a Metric Halo MIO2882 sound card, which is standard for professional level recordings in the audio industry. The stimuli were recorded at 44,100 Hz sampling rate and 16-bit sample size – the standard CD quality. All Audio

stimuli were treated to normalize any intensity anomalous, to improve signal-noise ratio and to eliminate any background noise. The wave files were then segmented using Sound Forge Pro 10.0a - Advanced Audio Waveform Editor (2003-2014 Sony Creative Software) to control the length of silence before and after the sound signal. All stimuli were evaluated by two objective non-linguists listeners in order to assure its validity.

4.2. Data acquisition

All prosodic tasks were presented using E-Prime software (Psychology Software Tools, inc.) to enable data collection of both accuracy rates and reaction times. In each task, the instructions – presented on the screen – were read out to the participants to confirm clarity of tasks requirements. A training trial of 4 to 6 stimuli followed. In each task, an auditory stimulus was played to which the participant had to response using one of two response keys (0 and 1 counterbalanced). The next stimulus was presented 1500ms followed the participant's response. Throughout the administration of the experiment the experimenter gave the participants a general positive feedback for their cooperation and willingness. The participants did not receive at any time any indication regarding their performance in terms of accurateness.

4.3. General design of the PROSA battery

The PROSA battery consists of two task modes, discrimination and comprehension; where within each mode, prosodic abilities were evaluated for grammatical, pragmatic and affective functions of prosody.

4.3.1. ***The prosodic discrimination tasks array*** consists of seven auditory same-different judgment tasks in which participants were asked to decide whether two consecutive stimuli (sentences/words) sound identical. Judgment in these tasks was based on perceptual discrimination and does not require access to the meaning level of the utterance.

Task description and group results of the discrimination section of the PROSA battery are presented in §5.

(38) Discrimination tasks

Grammatical tasks	Pragmatic tasks	Affect tasks
Lexical stress	Contrastive Focus	Positive vs. Negative affect Word level / Sentence level
Syntactic phrasing		
Question vs. Statement Word level / Sentence level		

4.3.2. ***The prosodic comprehension tasks array*** consists of nine tasks aiming to evaluate participants' ability to access utterance meaning when it is modulated by prosodic information. These tasks are designed to assess participants' competence in understanding prosodic contrasts and evaluate their ability to rely on prosodic cues in the process of interpreting and integrating linguistic and extralinguistic information in order to decode meanings and implications conveyed in speech.

(39) Comprehension tasks

Grammatical tasks	Pragmatic tasks	Affect tasks
Lexical stress picture matching	Focus sensitive Negation Picture matching	Positive vs. Negative affect Word level / Sentence level
Syntactic phrasing picture matching	Focus - Suitable answer judgment	
Question-Statement judgment word level / Sentence level	Focus- suitable answer picture matching	

Task description and group results of the comprehension section of the PROSA battery are presented in §6.

5. PROSA discrimination tasks – task description and group analysis

This section provides detailed description of each discrimination task followed by a group result analysis comparing the performance of the AS test-group with control results.

5.1. Prosodic grammatical discrimination tasks – task description

The grammatical discrimination section of the PROSA battery comprises of 4 judgment tasks aimed to evaluate the participants' ability to distinguish between stimuli which differ in lexical stress, syntactic phrasing and sentence/word denotation (question or statement).

5.1.1.*Lexical stress (discrimination task)*: In this task the participants were asked to decide whether two consecutive words sound identical. The task consisted of 32 pairs of words, 16 of which differed in their stress pattern leading to a different lexical meaning (40a), 5 pairs were fillers in which the two words shared stress pattern and differed in one vowel, leading, as well, to a different lexical meaning (40b), and 9 items were identical pairs of words (40c).

(40) Lexical stress discrimination task

	Word 1		***Word 2***	
a.	**bó**ker	*'morning'*	bo**kér**	*'cowboy'*
b.	ki**sé**	*'chair'*	ki**sá**	*'covered'*
c.	**ó**xel	*'food'*	**ó**xel	*'food'*

5.1.2. *Syntactic phrasing (discrimination task)*: In this task the participants were asked to decide whether two consecutive sentences sound identical. The task consisted of 40 pairs of sentences, 21 of which differed in their phrasing, thus leading to a different meaning (41), 19 items were identical pairs of sentences (42).

Out of the 21 non-identical pairs of sentences, 14 pairs were simple sentences which differed in their complement structure. In these sentences a sequence of two consecutive words was realized as two separate noun complements or as one compound complement, as a result of intonation phrasing (41a). The other 7 pairs of non-identical sentences consisted of complex sentences containing a relative clause

(41b) or coordination structure (41c). In these sentences the change of phrasing affected clause structure.

Out of the 19 identical pairs of sentences, 15 were simple sentences (see (42a)), and 4 were complex sentences with a relative clause (42b) or coordinate construction (42c).

(41) Syntactic phrasing discrimination task – non identical pairs

	Sentence 1	***Sentence 2***
a.	ba-xatuna axalti salat, perot ve-uga	ba-xatuna axalti salat perot ve-uga
	'In the wedding I ate a salad, fruit and a cake'	*'In the wedding I ate a fruit-salad and a cake'*
b.	kʃe-ha-park male, yeladim nehenim yoter	kʃe-ha-park male yeladim, nehenim yoter
	'When the park is crowded, children have more fun'	*'When the park is crowded with children, (Arb-pro) it is more fun'*
c.	nikiti et ha-miklaxat ve-ha-mitbax. adayin meluxlax	nikiti et ha-miklaxat, ve-ha-mitbax adayin meluxlax
	'I have cleaned the bathroom and the kitchen. It is still a mess'	*'I have cleaned the bathroom, and the kitchen is still a mess'*

(42) Syntactic phrasing discrimination task – identical pairs

	Sentence 1	***Sentence 2***
a.	al ha-ʃulxan yeʃ kosot, yayin ve-perot	al ha-ʃulxan yeʃ kosot, yayin ve-perot
	'On the table there are glasses, wine and fruit'	*'On the table there are glasses, wine and fruit'*
b.	kʃe-ha-kviʃ amus, rexavim nosim leat	kʃe-ha-kviʃ amus, rexavim nosim leat
	'When the road is busy, vehicles drive slowly'	*'When the road is busy, vehicles drive slowly'*
c.	axalti et ha-of, ve-ha-marak niʃar le-maxar	axalti et ha-of, ve-ha-marak niʃar le-maxar
	'I've ate the chicken, and the soup is left for tomorrow'	*'I've ate the chicken, and the soup is left for tomorrow'*

5.1.3. *Question vs. Statement (discrimination tasks):* The question-statement condition was assessed in two separate tasks – sentence level discrimination task and word level discrimination task. The participants heard two consecutive stimuli, a pair of sentences or a pair of words, and were asked to decide whether these two stimuli sound identical. The sentence level task comprised of 20 items, 12 of which differed in their interpretation as interrogatives or declaratives, leading to a different semantic meaning in terms of truth value (see (43a) below). 8 items consisted identical pairs of sentences (either a pair of declaratives or a pair of interrogatives, see (43b-c). The word level task consisted of 18 items; all were Hebrew forenames that were pronounced in a manner of question or in a manner of a statement. 11 of the name pairs differed in manner (44a), and 7 were identical ((44b-c) below).

(43) Question vs. statement discrimination task – sentence level

	Sentence 1	***Sentence 2***
a.	ha-yalda zarka et ha-kadur**.**	ha-yalda zarka et ha-kadur**?**
	*'The girl threw the ball**.**'*	*'The girl threw the ball**?**'*
b.	ha-yalda litfa et ha-xatula**.**	ha-yalda litfa et ha-xatula**.**
	*'The girl petted the cat**.**'*	*'The girl petted the cat**.**'*
c.	ha-yeled axal tapuax**?**	ha-yeled axal tapuax**?**
	*'The boy ate an apple**?**'*	*'The child ate an apple**?**'*

(44) Question vs. Statement discrimination task – word level

	Word 1		***Word 2***	
a.	Amálya.	*'Amalya.'*	Amálya**?**	*'Amalya**?**'*
b.	Avrahám**.**	*'Abraham.'*	Avrahám**.**	*'Abraham.'*
c.	Tehilá**?**	*'Tehila?'*	Tehilá**?**	*'Tehila?'*

5.2. Prosodic grammatical discrimination tasks – group analysis

The following table in (45) presents the results of the grammatical discrimination tasks, comparing the two research groups. The table specifies the percentage (*% error*) and the quantity (*No. error*) of errors the two groups performed in each of the

four grammatical discrimination tasks. Significant differences between the groups are indicated in red and marked by an asterisk (*p<0.05, **p<0.01). The size of control group varied across tasks and is indicated in the right column for each task (*n*).

(45) Grammatical discrimination tasks – group analysis

	Grammatical tasks	***AS test group*** *(n=9)*		***Control group***		
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***	***n***
a.	Lexical stress	**1.0%** *(1.5)*	3/288	**1.3%** *(3.2)*	6/480	n=15
b.	Syntactic phrasing	**4.4%** *(3.1)*	16/360	**1.9%** *(3.5)*	12/640	n=16
c.	Q-S – sentence	**3.3%** *(4.7)*	6/180	**1.0%** *(2.5)*	4/400	n=20
d.	Q-S – word	**7.4%** *(12.3)*	12/162	**0.3%** *(1.2)*	1/360	n=20

Table (45) indicates no significant variance between the two groups in the *Grammatical discrimination tasks*. However, the results of the *question vs. statement – word level task* (45d) reflect relatively high variability between AS participants, and a noticeable difference in percentage of errors between the AS test-group and the control group, as indicated by the comparison *per subject* in (45) above (U=53.5, p=0.089). The *question vs. statement – word level task* was in fact one of the single cases in which the results of the comparison *per item* were not in accordance with the results of the comparison *per subject* in terms of statistical significance. Result of the comparison *per item* were in fact significant in this case, emphasizing the difference between the two groups (U=88.5, p=0.02). Individual analysis of the participants' performance in this task (see table (98) in section 8) indicates only four AS participants as outliers when compared to the control group. It is important to note that these four AS participants are responsible for the vast majority of errors in this task.

5.3. Prosodic pragmatic discrimination tasks – task description

The pragmatic discrimination section of the PROSA battery comprises of a judgment task aimed to evaluate the participants' ability to distinguish between stimuli which differ in contrastive focus.

5.3.1. *Contrastive focus (discrimination task)*: In this task the participants were asked to decide whether two consecutive sentences sound identical. The task consisted of 20 items, 12 of which differed in their focused element (either the object or the subject of the sentence), leading to a different pragmatic interpretation (46a), 8 items were identical pairs of sentences (46b-c).

(46) Contrastive focus discrimination task

	Sentence 1	***Sentence 2***
a.	ha-[YELED]$_F$ axal tapuax	ha-yeled axal [TAPUAX]$_F$
	'The BOY ate an apple'	*'The boy ate an APPLE'*
b.	he-yalda lixlexa et ha-[RICPA]$_F$	he-yalda lixlexa et ha-[RICPA]$_F$
	'The girl mucked the FLOOR'	*'The girl mucked the FLOOR'*
c.	ha-[KELEV]$_F$ naʃax et ha-xatul	ha-[KELEV]$_F$ naʃax et ha-xatul
	'The DOG bit the cat'	*'The DOG bit the cat'*

5.4. Prosodic pragmatic discrimination tasks – group analysis

The following table (47) presents the performance of the two research groups in the pragmatic discrimination task.

(47) Pragmatic discrimination task – group analysis

Pragmatic tasks	***AS test group*** *(n=9)*		***Control group***		
	% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***	***n***
Contrastive focus	**15.0%**** *(17.8)*	(27/180)	**0.5%** *(1.5)*	2/400	n=20

**p<0.01

Table (47) indicates a distinct and significant difference between the two groups in the *Contrastive focus* task (U=34, p=0.009). While the control group responded incorrectly in only 0.5% out of their total responses, the AS test group responded incorrectly thirty times more, i.e., their incorrect responses accounted for 15% of the total responses. An individual analysis of the participants' performance in this task (discussed in section 8) indicates that the performance of six (out of 10) AS participants was significantly poorer than that of the control group.

5.5. Prosodic affect discrimination tasks – task description

The affect discrimination section of the PROSA battery comprises of two judgment tasks, which aim at evaluating the participants' ability to distinguish between stimuli that differ in the affect in which it was uttered. Positive affect – happy/contented manner vs. Negative affect – unhappy/discontented manner.

5.5.1. *Positive vs. negative affect (discrimination tasks)*: The affect condition was assessed in two separate tasks – sentence level discrimination task and word level discrimination task. The participants heard two consecutive stimuli, a pair of sentences or a pair of words, and were asked to decide whether these two stimuli sounded identical.

The sentence level task comprised of 22 pairs of sentences. The sentences in this task were emotionally neutral in lexical and semantic terms, i.e. they did not contain words that reflect emotion directly and did not describe situations that are emotional in essence. Therefore, these sentences could be interpreted as bearing positive or negative meaning based solely on the intonation in which it was uttered. The sentences in this task were distributed as follows: in 14 of the pairs the two sentences differed in the emotion in which it was uttered, leading to a different interpretation of the speaker's state of mind (48a). 8 pairs consisted two identical sentences uttered in either a happy/contented manner or in a sad/discontented manner, (48b-c).

The word-level task consisted of 17 word pairs; all words in this task were Hebrew forenames (of 2-4 syllables) that were pronounced in a happy/contented manner or in a sad/discontented manner. In 10 of the name pairs the two words differed in affect (49a) and in 7 pairs the two words were identical (49b-c).

(48) Affect discrimination task – sentence level

	Sentence 1	***Sentence 2***
a.	kibalti ʃmonim ba-mivxan be-anglit ☺	kibalti ʃmonim ba-mivxan be-anglit ☹
	'I got an 80 on my English test'	*'I got an 80 on my English test'*
b.	ima kanta li sveder yarok ☹	ima kanta li sveder yarok ☹
	'Mom bought me a green sweater'	*'Mom bought me a green sweater'*
c.	od meat nelex liʃon ☺	od meat nelex liʃon ☺
	'Soon we will go to sleep'	*'Soon we will go to sleep'*

(49) Affect discrimination task – word level

	Word 1		***Word 2***	
a.	Amálya ☺	*'Amalya'*	Amálya ☹	*'Amalya'*
b.	Avrahám ☺	*'Abraham'*	Avrahám ☺	*'Abraham'*
c.	Tehilá ☹	*'Tehila'*	Tehilá ☹	*'Tehila'*

5.6. Prosodic affect discrimination tasks – group analysis

The following table in (50) presents the results of the two research groups in the affect discrimination tasks.

(50) Affect discrimination tasks – group results

	Affect tasks	***AS test group*** *(n=9)*		***Control group***		
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***	***n***
a.	Positive/Negative affect: *sentence level*	**9.1%**** *(7.7)*	18/198	**1.6%** *(2.6)*	7/440	n=20
b.	Positive/Negative affect: *word level*	**6.5%** *(7.0)*	10/153	**1.5%** *(0.5)*	5/340	n=20

**p<0.01

The comparison in (50a) indicates significant differences between the two groups in the *Positive vs. Negative affect - sentence level task* (U=27.5 p=0.004). This task was one of the few cases in which the results of the comparison *per subject* were

incompatible with the results of the comparison *per item* that were found to be non-significant in this case (U=173, p=0.12). No significant group differences were found in the word level *Affect* discrimination task ((54b) *per subject* U=53.5, p=0.09, *per item* U=131, p=0.65)). Individual analysis (see (86)) reveals that the performance of only four AS participants was significantly poorer than that of the control group in the *Affect* tasks. These four individuals were responsible for all the errors in these two tasks.

5.7. Interim summary - PROSA discrimination tasks - group analysis

The greatest and most prominent difficulty of the AS test-group in the PROSA battery *discrimination tasks* was evident in the *pragmatic – contrastive focus task* with a group average of 15% errors and significant difficulty that was reflected in both *per subject* and *per item* comparisons. Noticeable differences were also detected in the *sentence level - affect task* and in the *grammatical - question vs. statement - sentence level task*.

A central finding that emerges from the *discrimination tasks*' group analysis is the substantial variance within the AS group. As noted above, the performance of the AS test-group was found to be non-homogenous in some of the tasks, i.e. the group difficulty that was observed was the result of the poor performance of only some (and in some of the tasks - the minority) of the participants within the AS test-group. This aspect will be discussed in the *individual analysis* in section 8.

6. PROSA Comprehension tasks – task description and group analysis

This section provides a detailed description of each prosodic comprehension task, followed by an analysis of the AS group results.

6.1. Prosodic grammatical comprehension tasks – task description

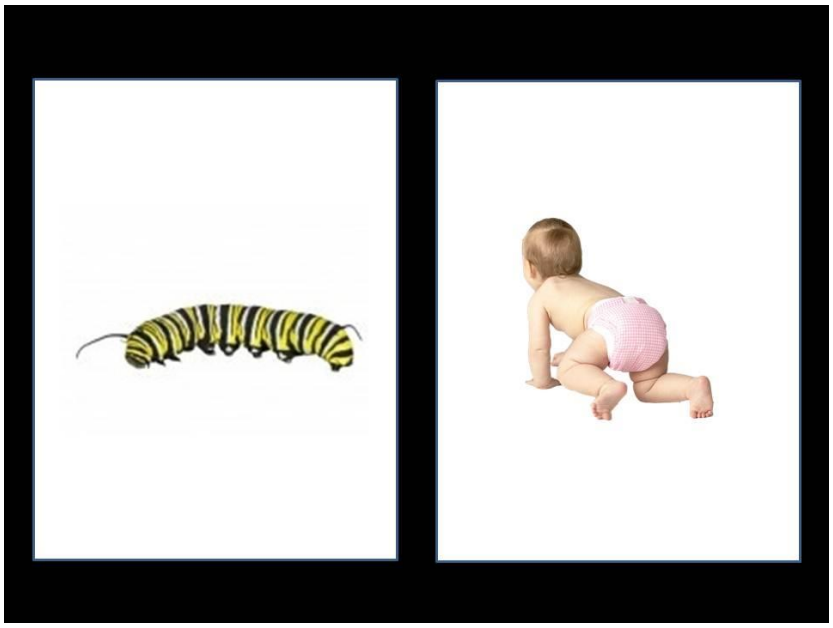
The grammatical comprehension section of the PROSA battery comprised of lexical stress, syntactic phrasing and sentence/word denotation (question vs. statement) tasks. These tasks were aimed to evaluate the participants' ability to use prosodic information in the process of interpreting and integrating linguistic material.

6.1.1. ***Lexical stress – picture matching (comprehension task):*** In this task the participants heard an auditory stimulus of a word and were asked to choose between two pictures, the one that better suits the word they have heard. The task consisted of 16 items, all disyllabic words. 8 words had a penultimate stress pattern (51a) and 8 had a final stress pattern (51b). The stimuli consisted of both verbs and nouns.

(51) Lexical stress comprehension task

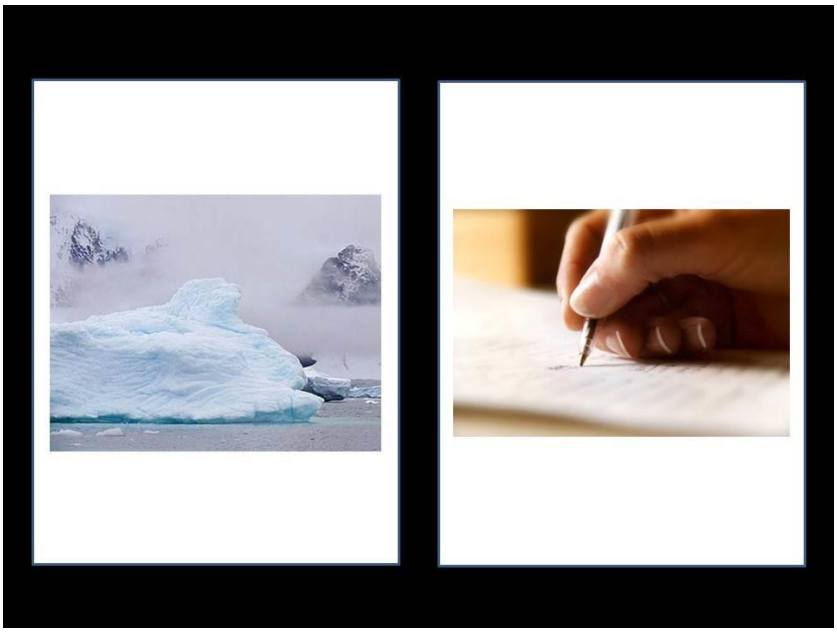
	Word		***Image***	
a.	**zá**xal	*'caterpillar'*	Image (56)	***zá****xal 'caterpillar'* <on the left> *za****xál*** *'crawled'* <on the right>
b.	ko**tév**	*'writes'*	Image (57)	***kó****tev 'pole'* <on the left> *ko****tév*** *'writes'* <on the right>

(52) Screen image for the word in (51a) - **zá**xal *'caterpillar'*



For the auditory stimuli in (51a), ***zá****xal* 'caterpillar', the participants were expected to choose the picture on the left. Had the auditory stimuli been *za****xál*** *'crawled'*, the picture of a crawling baby on the right would be more suitable.

(53) Screen image for the word in (51b) - ko**tév** *'writes'*



For the auditory stimuli in (51b) – *ko**tév*** 'writes', the participants were expected to choose the picture on the right. Had the auditory stimulus been ***kó**tev* 'pole', the picture on the left would suit the word.

6.1.2. *Syntactic phrasing - picture matching (comprehension task):* In this task, after hearing an auditory stimulus of a sentence, the participants were asked to choose out of two pictures the one that better suits the sentence they have heard. The phrasing of the sentences in this task was exclusively dependent on the intonation pattern in which it was uttered, determining whether a consecutive sequence of nouns should be interpreted as two separate nouns or as a compound. The task consisted of 23 sentences; all simple sentences with two or three complements. 11 sentences contained two complements, as in (54a), *kosot-yayin ve perot 'wine-glasses and fruits'*. In these sentences one of the complements was a compound (*kosot-yayin*) and the second was a simple noun (*perot*). The other 12 sentences contained three separate noun complements, as in (54b), *kadur, sal ve-maʃrokit 'a ball, a basket, and a whistle'*. The participants in this task heard an auditory stimulus of a sentence ((54) left column) and were requested to choose out of two pictures ((54) right column), the one which is compatible with the sentence they have heard.

(54) Syntactic phrasing comprehension task

	Sentence	Image	
a.	al ha-ʃulxan yeʃ kosot-yayin, ve-perot *'On the table there are wine-glasses, and fruits'*	Image (55)	kosot-yayin, ve-perot *'wine-glasses, and fruits'* *<on the right>* kosot, yayin, ve-perot *'glasses, wine, and fruits'* *<on the left>*
b.	ba-xag kibalti kadur, sal, ve-maʃrokit *'On the holiday I got a ball, a basket, and a whistle'*	Image (56)	kadur, sal, ve-maʃrokit *'a ball, a basket, and a whistle'* *<on the right>* kadur-sal, ve-maʃrokit *'a basketball, and a whistle'* *<on the left>*

(55) Screen image for sentence (54a) *al ha-ʃulxan yeʃ kosot-yayin ve-perot*

For the auditory stimulus in (54a) *al ha-ʃulxan yeʃ kosot-yayin ve-perot 'On the table there are wine glasses and fruit'* the participants were expected to choose the picture on the right. Had the auditory stimulus been *al ha-ʃulxan yeʃ kosot, yayin ve-perot 'On the table there are glasses, wine and fruit'*, the picture on the left would be suitable.

(56) Screen image for sentence (54b) *ba-xag kibalti kadur, sal ve-maʃrokit*

For the auditory stimulus in (54b), *ba-xag kibalti kadur, sal ve-maʃrokit 'On the holiday I got a ball, a basket and a whistle'*, the participants were expected to choose the picture on the right. Had the auditory stimulus been *ba-xag kibalti kadur-sal ve-maʃrokit 'On the holiday I got a basketball and a whistle'*, the picture on the left would suit the sentence.

In order to avoid answer strategies that could be dependent on rate of speech or on counting the number of complement, the objects were organized differently on the screen for every picture, as illustrated in (57) below.

(57) Syntactic phrasing - illustration of some possible objects' layouts

6.1.3. ***Question vs. statement - comprehension task (judgment task):*** The question vs. statement condition was assessed in a judgment task for sentence-level and word-level. The participants heard a sentence or a word and were requested to decide whether the speaker of the utterance was 'Asking a question', i.e. they were asked whether the stimulus they have heard was an interrogative expression or not. Due to the common tendency of the autistic population to give literal interpretations (Happé, 1993), it was important to state the instructions for this task in a way that will not evoke a potential ambiguity. In previous studies, autistic children were asked to distinguish interrogatives from declaratives by indication whether the speaker was 'Asking something' or 'Telling something' (Paul et al. 2005, Peppé et al. 2003, 2007). This potential problem was also emphasized in Chevallier et al. (2011) who noted that this form of instructions might affect the results' reliability since under a literal interpretation 'Asking' could be interpreted as a case of 'Telling'. Therefore, in the present task, in order to prevent the potential vagueness of the assignment, the instructions were formulated as a Yes/No question – 'Is the speaker asking a question?'. The task comprised of 18 sentences (58) and 18 words (59). All the word-level stimuli were Hebrew forenames (of 2-4 syllables). Half of the items in each level were uttered as a question and the other half were uttered as a statement.

(58) Question vs. statement comprehension task – sentence level

a. ha-yalda zarka et ha-kadur**?** *'The girl threw the ball**?**'*

b. ha-yalda zarka et ha-kadur**.** *'The girl threw the ball**.**'*

(59) Question vs. Statement comprehension task – word level

a. Amálya**?** *'Amalya**?**'*

b. Amálya**.** *'Amalya**.**'*

6.2. Prosodic grammatical comprehension tasks – group analysis

The following table in (60) presents the grammatical comprehension tasks results of the two groups.

(60) Grammatical comprehension tasks – group analysis

	Grammatical tasks	***AS test group*** *(n=9)*		***Control group***		
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***	***n***
a.	Lexical stress	**0.0%** *(0.0)*	0/144	**0.3%** *(1.4)*	1/304	n=19
b.	Syntactic phrasing	**3.4%** *(4.0)*	7/207	**2.3%** *(3.8)*	12/529	n=23
c.	Q-S – sentence level	**0.6%** *(1.7)*	1/162	**0.3%** *(1.2)*	1/342	n=19
d.	Q-S – word level	**2.5%** *(4.6)*	4/162	**0.3%** *(1.2)*	1/342	n=19

As shown in (60), there were no significant differences in the performance of the two groups in the four grammatical comprehension tasks.

6.3. Prosodic pragmatic comprehension tasks – task description

The pragmatic comprehension section of the PROSA battery included three different tasks involving *focus*. The focus of an utterance is considered to contain the utterance's informative content that cannot be inferred from the discourse.

6.3.1. ***Focus sensitive negation - picture matching (comprehension task):*** The interpretation of certain semantic operators, such as the negation operator or the particles *even* and *only* could be dependent on the position of focus within the sentence. This dependency between focus sensitive operators and the focal accent called *association with focus* and leads to meaning-sensitivity to prosody (Jackendoff 1972, Rooth 1999, Krifka 2006).

In this task, the participants heard 18 sentences in which the association of the negator with the focused expression influenced and modulated the pragmatic inference of the sentence.

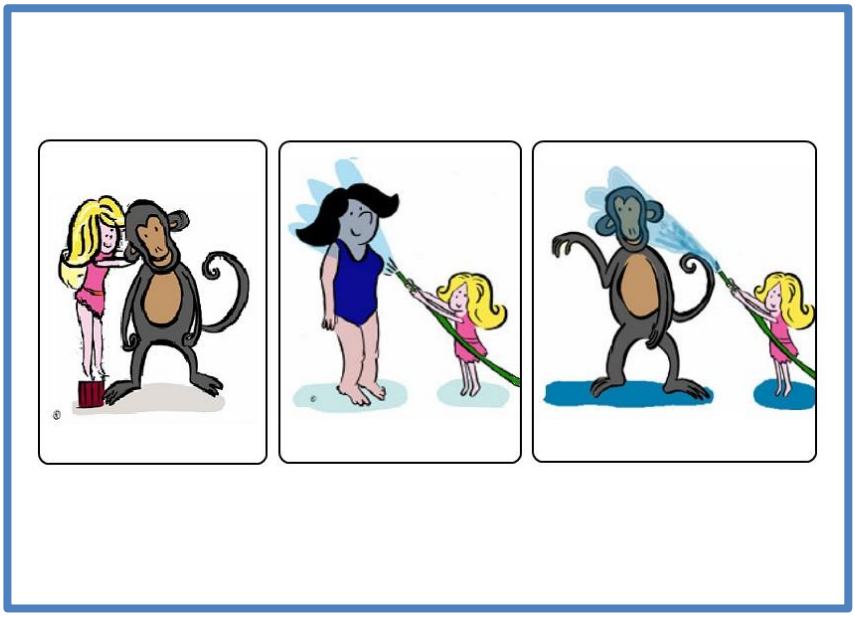
The participants were presented with a screen image of three pictures (61b) followed by an auditory stimulus of a sentence (61a). The participants were then asked to choose, out of the three pictures on the screen, the one that is most compatible with the sentence they have heard.

(61) Focus sensitive negation – *focused predicate*

a. ze lo naxon she-ha-yalda [MARTIVA]$_F$ et ha-kof

'It is not the case that the girl WETS the monkey'

b. Screen image for (61a):



The semantics of (61a) asserts the falseness of the entire proposition (as in (62)); therefore the option of choosing the picture on the right hand side, in which there is a girl who wets a monkey, is rejected.

(62) ¬ [girl wets monkey]

On the pragmatic level, the association of the negation operator with the focal accent strongly implies that there is in fact a true proposition, which is an alternative of the negated proposition in (62), in which the girl does not ***wet*** the monkey but is ***doing something else*** to it (e.g., 'the girl *feeds* the monkey, the girl *kisses* the monkey, the girl *pets* the monkey…').[14] In an intuitive sense, it appears as if the negation applies only to the focused constituent (***wet***s) rather than to the entire sentence such that in the case of (61) the speaker denies the predicate while the remainder of the sentence is not negated. The decision between the left and the middle pictures in (61b) is therefore expected to be influenced by and result from this prominent implication. In

[14] The exact nature of this apparent implication is somewhat controversial. In order to avoid the controversy, I will refer to these inferences henceforth as mere *implications* and will not commit to a specific type of implication (e.g. conventional implicatures, presuppositions, etc.). For further discussion of the interaction of negation and focus see Herburger (2000), Beaver and Clark (2008) among others.

the case of image (61b), the participants were expected to reject the picture in the middle, in which the girl still performs an act of ***wetting*** upon an object which is not a monkey, and choose the picture on the left in which the girl ***pets*** a monkey.

An interesting observation emerged from the comments of some of the control participants at the end of this task. Many of the control participants were commenting that there were in fact two suitable pictures for the negation sentences, indicating that both the middle and the left picture in the example above (61b) are appropriate selections for the sentence in question (61a). However, this prima facie ambiguity did not affect their decision in practice since the control group's performance in this task reflected high success rates (with only 1.3% errors in the negation sentences; see group results in (74-76)). This apparent incompatibility between the high accuracy rates of the control participants and their low confidence regarding their performance strongly suggest that the participants were not aware of this aspect of their linguistic knowledge and to the influence of focus on their pragmatic inference.

Table (63) presents examples of the various negation sentences that were used in the *focus sensitive negation – picture matching task.* The items in this task included sentences with different focal positions – focused subject, focused predicate and focused object.

(63) Focus sensitive negation – focal positions

	Focused constituent	***Sentence***
a.	Focused subject	ze lo naxon she-ha-[YELED]$_F$ doker et ha-drakon
		'It is not the case that the BOY stabs the dragon'
b.	Focused predicate	ze lo naxon she-ha-yalda [MARTIVA]$_F$ et ha-kof
		'It is not the case that the girl WETS the monkey'
c.	Focused object	ze lo naxon she-ha-yeled menašek et ha-[DOV]$_F$
		'It is not the case that the boy kisses the BEAR'

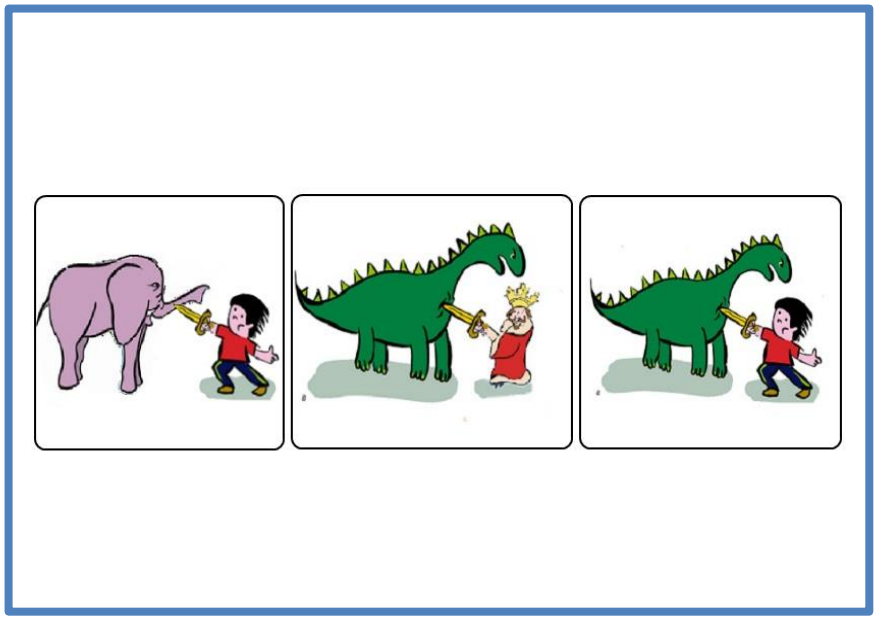
Sentence (64a) below exemplifies a case of a focused subject:

(64) Focus sensitive negation - focused subject

a. ze lo naxon she-ha-[YELED]$_F$ doker et ha-drakon

'It is not the case that the BOY stabs the dragon'

b. Screen image for (64a):



In this sentence the implication that arises from the association of the negation operator with the focused subject is that somebody, who is not the boy, is stabbing the dragon. This implication is expected to lead the participants to choose the picture in the middle, in which a king is stabbing a dragon.

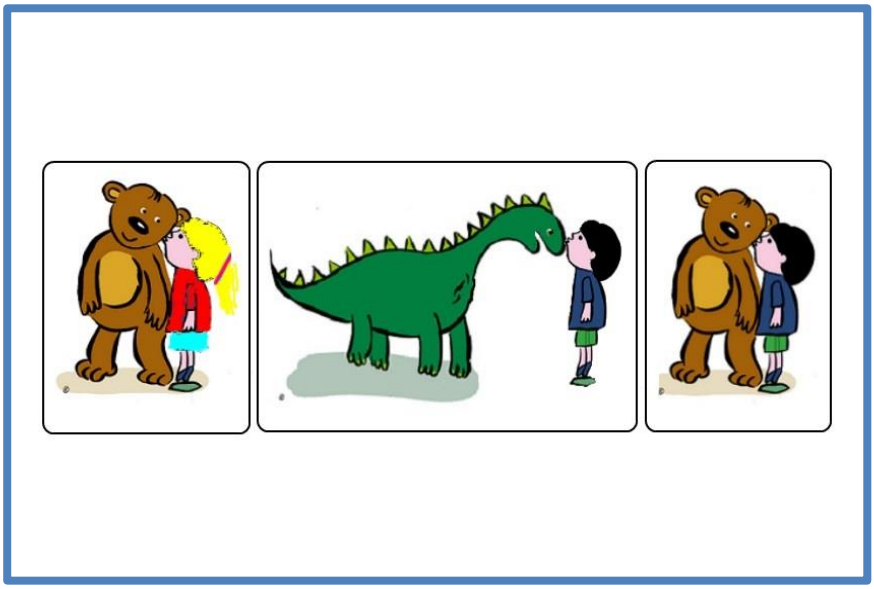
The following sentence in (65a) presents a case of a focused object:

(65) Focus sensitive negation - focused object

a. ze lo naxon she-ha-yeled menašek et ha-[DOV]$_F$

'It is not the case that the boy kisses the BEAR'

b. Screen image for (65a):



In this sentence the focal element is the object and the participants were expected to choose the picture in the middle in which there is a boy who performs an act of kissing, but he kisses a dragon and not a bear.

The operation that is assumed to underlie the process of *association with focus* requires the formation of a set of alternatives for the focused expression (Rooth 1985, 1992 and related work). This operation, which will be discussed in detail in section 10, is not limited to the processing of focused expressions and features several other processes of semantic and pragmatic interpretation, for instance - the interpretation of *Scalar Implicatures* (Rooth 1992, Fox and Katzir 2011 among others).

Therefore, in order to evaluate whether the mere operation of *generating alternatives* could be impaired, the current task included an additional type of sentences, which required the computation of *Scalar Implicatures* (this pragmatic condition was already presented in the *Language skills evaluation* in section 3.5.4.2).

A crucial difference between the *focus sensitive negation* sentences and the *Scalar Implicatures* sentences could be found in the trigger for alternatives computation. In the *Scalar Implicature* sentences the trigger is lexical, the word *xelek 'some'*, which evokes alternatives such as *'most'* and *'all'* (e.g. (35), repeated in (66) below), whereas

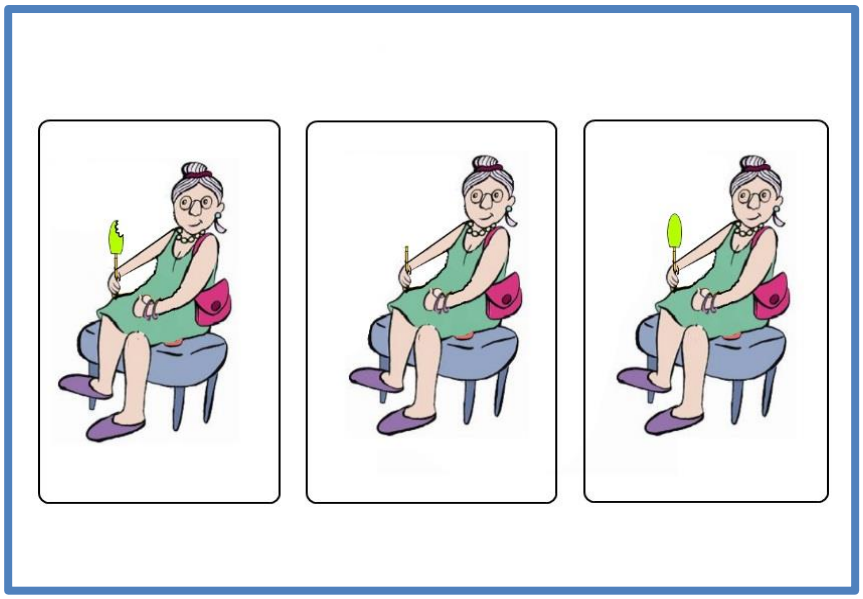
in the *negation sentences*, the trigger for generating alternatives is purely prosodic - the focal element.

(66) Scalar implicatures

a. ha-savta axla <u>xelek</u> me-ha-kartiv

'The grandmother ate <u>some</u> of the popsicle'

b. Screen image for (66a):



The use of a weaker statement, from an ordered scale of statements, implicates that none of the stronger statements in the scale was valid in the given context (Horn 1972, Grice 1975). Based on this common understanding, the expected response to the example above would be choosing the left picture in (66b), over the centered one, as most compatible with the sentence in (66a).

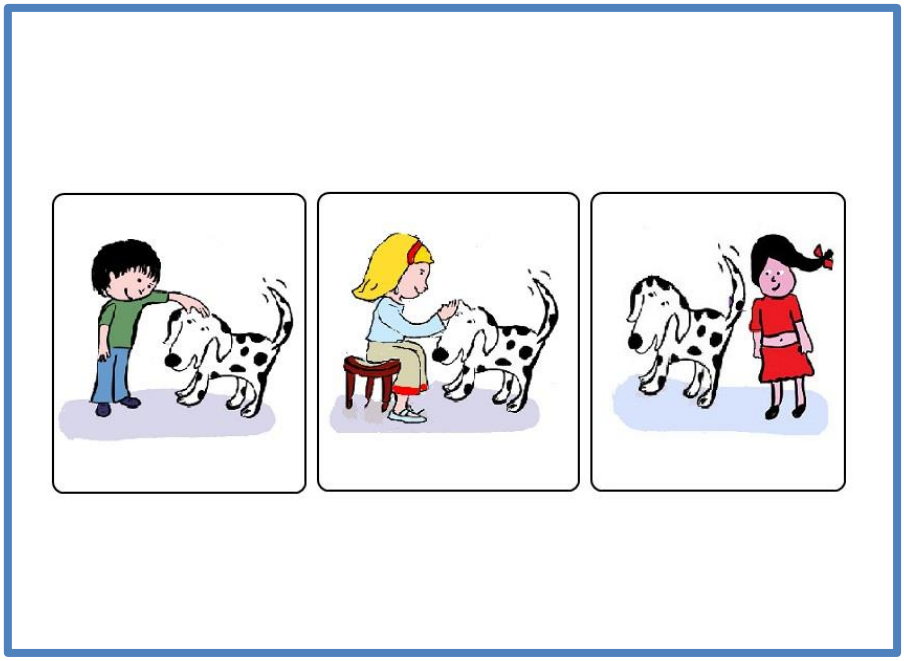
The present task also included simple sentences with neutral prosody as fillers (as exemplified in (67) below).

(67) Simple sentences: fillers

a. ha-yalda melatefet et ha-kelev

'The girl pets the dog'

b. Screen image for (67a)



This *focus sensitive negation* task included a total of 34 sentences. The distribution of sentence types in the task is detailed in (68).

(68) Association with focus - Sentence types

	Sentence type	***Sub-type***	***No. of items***
a.	Negation	Focused subject	5
		Focused predicate	8
		Focused object	5
b.	Scalar implicature	-	7
c.	Simple	-	9

6.3.2. ***Focus - suitable answer judgment (comprehension task):*** There is a solid link between questions and the position of focus in answers. In this appropriateness judgment task the participants heard a question-answer pair and were asked to decide whether, in their opinion, the answer suits the question.

The task consisted of 36 question-answer pairs. In 9 pairs a semantic mismatch between the question and the answer was evident (69a). In these sentences the participants were expected to judge the answer as unsuitable response for the question they have heard.

9 other question-answer pairs presented a semantic and a prosodic match of question and answer (69b). In these sentences, the participants were expected to judge the answer as suitable response for the question. The remaining 18 question-answer pairs demonstrated a prosodic mismatch between the question and the answer, such that there was no correspondence between the focused constituent in the answer and the Wh-element in the question (69c). The expected judgment in these cases was to judge the answer as unsuitable for the question.

(69) Focus - suitable answer judgment task - sentence types

	Sentence type	***Question***	***Answer***	***No. of items***
a.	Semantic mismatch	mi menaʃek et ha-dov?	ha-PIL martiv et ha-arye	9
		'Who kisses the bear?'	*'The ELEPHANT wets the lion'*	
b.	Match	et mi ha-yeled menaʃek?	ha-yeled menaʃek et ha-DOV	9
		'Who does the boy kiss?'	*'The boy kisses the BEAR'*	
c.	Prosodic mismatch	et mi ha-yeled menaʃek?	ha-YELED menaʃek et ha-dov	18
		'Who does the boy kiss?'	*'The BOY kisses the bear'*	

6.3.3. ***Focus – suitable answer picture matching (comprehension task):*** The third focus comprehension task was a picture matching task in which the focal element was once again in a context of an answer to a question. In this task, the participants heard a question-answer pair. After the auditory stimulus, two pictures appeared on the screen and the participants were asked to choose the picture that was compatible with the answer they have heard. This task consisted of 24 question-answer pairs. All pairs matched in semantic terms, i.e. the answer matched the question in content and was a

suitable and direct response to the question with respect to meaning. In 10 of the question-answer pairs the answer also matched the question in prosodic terms. The focused constituent in the answer corresponded to the Wh-element in the question (70a). In the other 14 pairs the question and the answer were prosodically mismatched (70b).

(70) Focus - suitable answer picture matching task – Sentence types

	Sentence type	***Question***	***Answer***	***No. of items***
a.	Match	et mi ha-pil martiv?	ha-pil martiv et ha-ARYE	10
		'Who does the elephant wet?'	*'The elephant wets the LION'*	
b.	Prosodic mismatch	mi doker et ha-drakon?	ha-yeled doker et ha-DRAKON	14
		'Who stabs the dragon?'	*'The boy stabs the DRAGON'*	

This present task was designed to evaluate reaction times under the assumption that the response of individuals with normal prosodic abilities might be slowed as a result of prosodic incompatibility. The response of individuals who suffer from a deficit in pragmatic aspects of prosody, however, should be less affected by prosodic mismatches. It was assumed, therefore, that if the AS participants will prove to be less sensitive to prosody and to the inferences that are triggered by the focal accent in comparison with the control group, they will be less confused or delayed in their reaction in response to a prosodic mismatch between questions and answers.

In terms of accuracy, in both conditions (prosodic mismatch / match) there was only one picture which was semantically compatible with the question-answer auditory stimulus, therefore, the participants of both the AS test-group and the control group were expected to have difficulties in choosing the correct picture.

The following example (71) demonstrates a case of matched question-answer pair:

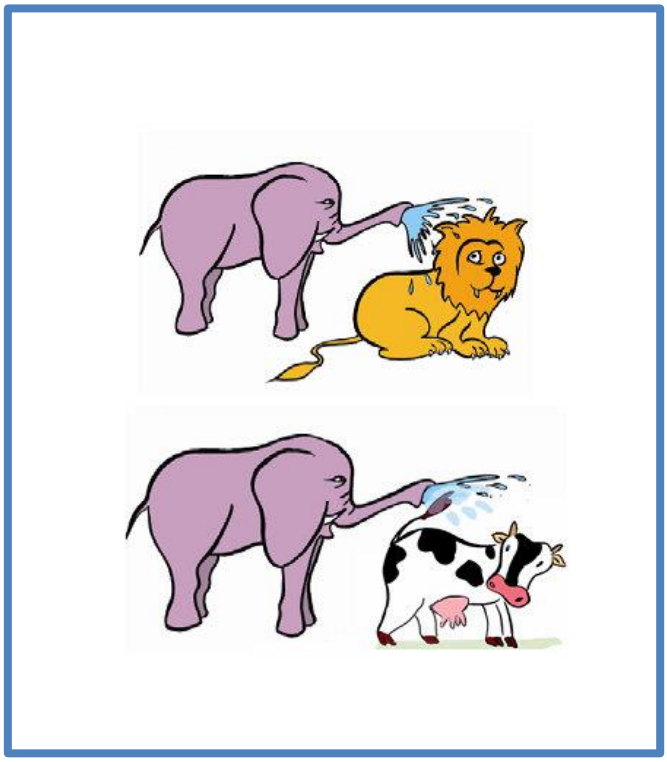
(71) Focus – suitable answer picture matching task:

Matched question-answer pair

a. Q: et mi ha-pil martiv? *'Who does the elephant wet?'*

A: ha-pil martiv et ha-ARYE *'The elephant wets the LION'*

b. Screen image for (71a)



In the above example, only the top picture, of an elephant wetting a lion, that is compatible with the auditory stimulus in (71a). The bottom picture involves an animal that is not included in the answer, nor in the question; hence it is completely unsuitable as a response for this stimulus. In this case the participants were expected to indicate the top picture as compatible with the stimulus they have heard.

The example in (72) presents a case of prosodic mismatch between question and answer.

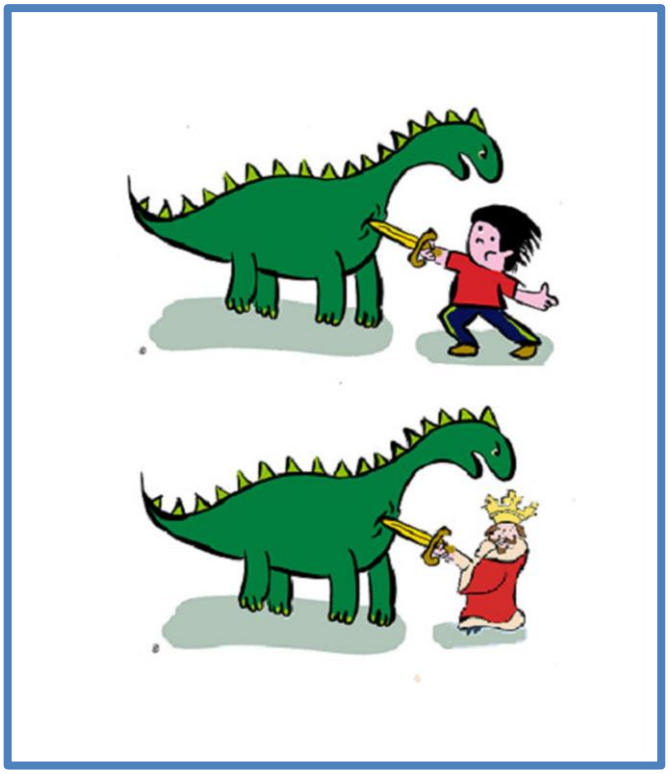
(72) Focus – suitable answer picture matching task:

Prosodically mismatched question-answer pair

a. Q: mi doker et ha-drakon? *'Who stabs the dragon?'*

A: ha-yeled doker et ha-DRAKON. *'The boy stabs the DRAGON'*

b. Screen image for (72a)



In this second example (72) there is a prosodic mismatch between the question, which asks about the subject, and the answer, in which the focused element is the direct object. Therefore, there is no correspondence between the Wh-element in the question and the focused element in the answer. Nevertheless, as in the previous example (71), only one picture is compatible with the stimulus. Hence, the two participant groups were expected to choose the suitable picture in both conditions.

6.4. Prosodic pragmatic comprehension tasks – group analysis

The following table in (73) presents the results of the two groups in the pragmatic comprehension tasks. The figures in bold indicate the percentage of errors each group performs. Figures in the *No. error* column refer to the amount of errors (out of the

total trials in a task). Significant differences between the two groups are indicated in red and marked by an asterisk.

(73) Pragmatic comprehension tasks – group analysis

	Pragmatic tasks	*AS test group* (*n*=9)		*Control group*		
		% error (*SD*)	*No. error*	*% error* (*SD*)	*No. error*	*n*
a.	Focus sensitive negation picture matching	**16.0%**** *(10.7)*	49/306	**0.7%** *(1.5)*	6/850	n=25
b.	Focus - suitable answer judgment	**36.1%**** *(16.8)*	117/324	**7.1%** *(12.4)*	54/756	n=21
c.	Focus - suitable answer picture matching	**0.9%** *(1.7)*	2/216	**3.4%** *(5.6)*	19/528,	n=22

*p<0.05, **p<0.01

The figures in (73) display significant differences between the performances of the two groups in two out of the three focus comprehension tasks. The results of the first two tasks (73a and 73b) indicate that the performance of the Asperger test-group was substantially worse than that of control (U=30, p=0.001, U=14.5, p<0.001 respectively). The results of the third task, though not significant (U=75.5, p=0.32), show an opposite trend and present poorer performance of the control group (73c).

It should be noted that the percentage of errors in the above table presents raw analysis and is not specified to conditions. The actual percentage of errors in the target-items is much higher and will be presented separately for each task in sections 6.4.1-6.4.3.

6.4.1. *Focus sensitive negation - group analysis*

When considering the different sentence types of the *focus sensitive negation* task (74 below), it is clear that the Asperger's group did not show any difficulty in selecting the correct picture for most of the *simple sentence* stimuli (74c) and for those sentences which required computation of *scalar implicatures* (74a). The AS test-

group performance did not differ from control for these types of stimuli (*simple sentences*: U=87.5, P=0.337, *scalar implicature sentences*: U=112.5, p=0.982). The AS test-group did, however, fail to select the correct picture for almost a third of the *negation sentences* (74b) and differed significantly from the control group in this condition (U=30, p=0.001).

(74) Focus sensitive negation - group analysis

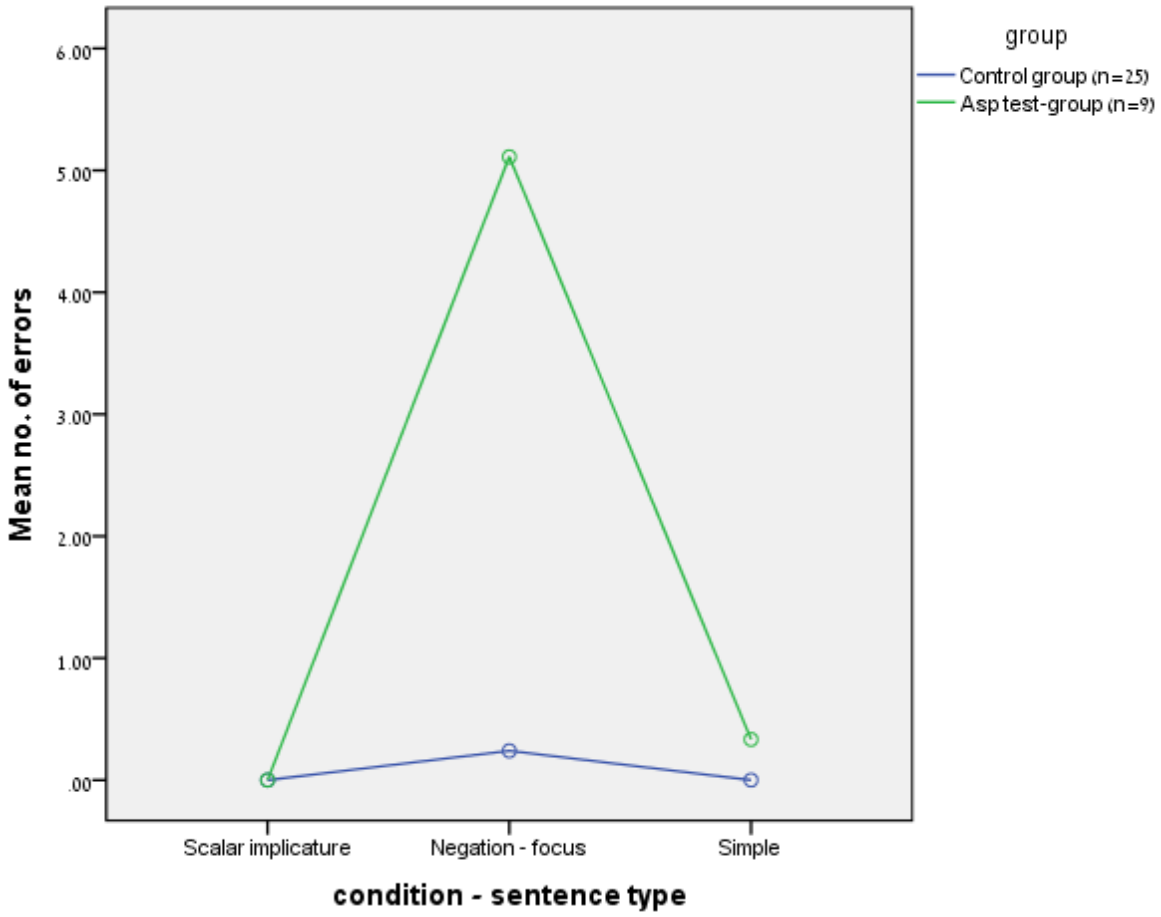
	Sentence type	***AS test group*** *(n=9)*		***Control group*** *(n=25)*	
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***
a.	Scalar implicatures - *some*	**0.0%** *(0.0)*	0/63	**0.0%** *(0.0)*	0/175
b.	Negation sentences - *focus*	**28.4%**** *(17.7)*	46/162	**1.3%** *(2.8)*	6/450
c.	Simple sentences - *fillers*	**3.7%** *(7.4)*	3/81	**0.0%** *(0.0)*	0/225,

*p<0.05, **p<0.01

In order to further evaluate the effect of sentence type in this task, a 2x3 *repeated measures ANOVA* with a *between subject factor* of *group* 2(AS test-group/Control group) and a *within subject factor* of *Sentence type* 3(Scalar Implicatures/Negation/Simple) was carried out. The analysis yields significant main effect of *group* (AS test-group M=1.82, SD=0.22, Control group M=0.08, SD=0.13, F(1,32)=45.2, p<0.001) indicating that overall mean of errors made by the AS test-group throughout the task was significantly higher than the overall mean of errors made by Controls. The analysis further reveals significant main effect of *Sentence type* (Scalar M=0, SD=0, Negation M=2.68, SD=0.34, Simple M=0.17, SD=0.07, F(1.05,33.45)[15]=64.3, p<0.001) indicating that the three sentence types significantly differ in means of errors. In addition, a significant interaction between *group* and *sentence type* was evident (F(1.05,33.45)=52.99, p <0.001). Post-hoc tests (using Bonferroni correction) indicate the source of this interaction to be the AS group's high means of errors in the *negation sentences* (see (75)).

[15] Based on Mauchly's test the assumption of sphericity has been violated ($\chi^2(2)=75.59$, p<0.001) therefore degrees of freedom where corrected using Greenhouse-Geisser estimates of sphericity (ε=0.52)

(75) Focus sensitive negation – within group comparison



In a pairwise comparison of the three sentence types, differences in means of errors within the control group did not reach significance, whereas the performance of the AS test-group in the *negation sentences* differed significantly from their performance in the *scalar implicature* sentences (Negation M=5.1 SD=1.12, Scalar M=0 SD=0, p=0.006) and in the *simple sentences* (Negation M=5.1 SD=1.12, Simple M=0.3 SD=0.24, p=0.004). No significant difference was found between the *simple sentences* and the *scalar implicature* sentences (Simple M=0.3 SD=0.24, Scalar M=0 SD=0, p=0.585).

The prominent difference in the performance of the AS test-group in the first two conditions (*scalar implicature* sentences and *negation sentences*) suggest that the difficulty observed in the *negation sentences* could not result from a general deficit in the AS participants' ability to compute implicatures or to form a set of alternatives for an element in the sentence, since these mechanisms operate in both types of sentences. This issue will be further discussed in section 10.3.2.

Another aspect of the results that should be addressed refers to the various positions of the focal element that were examined. (76) presents group analysis of the *negation sentences* according to focus position.

(76) Focus sensitive negation- Focused positions

	Negation sentences	***AS test group*** *(n=9)*		***Control group*** *(n=25)*	
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***
a.	Focused *Object*	**22.2%**** [16] *(22.0)*	10/45	**0.8%** *(3.9)*	1/125
b.	Focused *Predicate*	**38.9%**** *(23.9)*	28/72	**2.0%** *(5.8)*	4/200
c.	Focused *Subject*	**17.8%*** *(17.5)*	8/45	**0.8%** *(3.9)*	1/125,

*p<0.05, **p<0.01

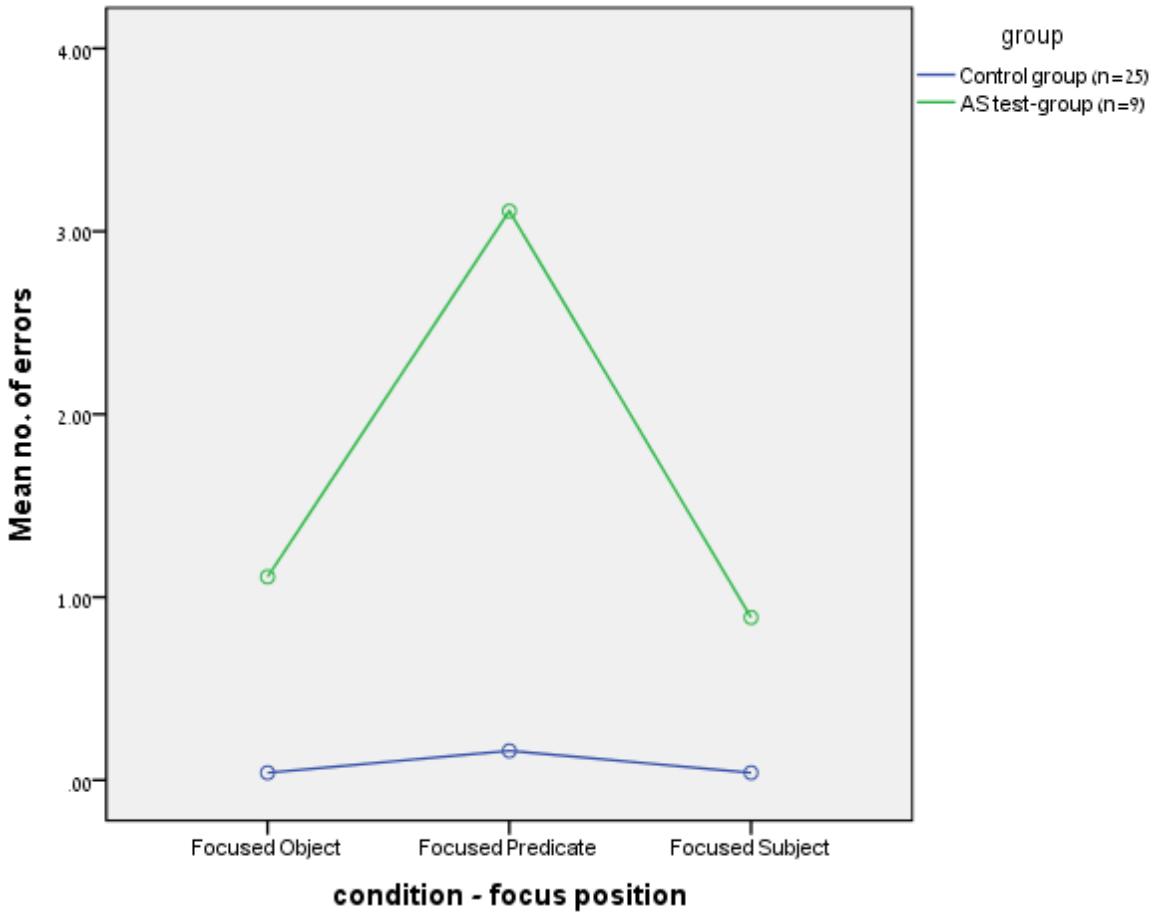
The analysis in (76) verifies that the substantial differences between the two research groups are attested in all three positions (Object: U=41, p=0.006, Predicate: U=28.5, p=0.001, Subject: U=53, p=0.02). However, it is important to note that the three conditions were not equally difficult and that both groups showed the poorest performance in the *focused predicate* condition.

A 2x3 *repeated measures ANOVA* with a *between subject factor* of *group* 2(AS test-group/Control group) and a *within subject factor* of *focus position* 3(Object/ Predicate/Subject) was carried out. The analysis yields significant main effects of *group* and *focus position* as well as interaction between these two factors. Main effect of *group* indicate that regardless of focus position, accuracy measures of the AS test-group were generally lower than those control (AS test-group M=1.7, SD=0.19, Control group M=0.08, SD=0.12, F(1,32)=62.2, p<0.001). Main effect of *focus position* indicate that the three focus positions differ significantly (Object M=0.58, SD=0.12, Predicate M=1.64, SD=0.21, Subject M=0.46, SD=0.1, F(1.67,53.28)

[16] The results of the comparison *Per item* of the AS test-group and the control group were found to be non-significant for *Focused Object* (U=3.5, p=0.07) and *Focused subject* (U=6.5, p=0.25). This inconsistency between comparison *per subject* and comparison *per item* in this case, could be due to the small number of items (5 for each sentence type). Comparison *per item* was found to be significant for the *Focused Predicate* sentences (U=11, p=0.03)

=64.3, p<0.001) indicating that the three sentence types significantly differ in means of errors. In addition, a significant interaction between *group* and *sentence type* was evident (F(1.05, 33.45)=27.8, p <0.001)[17]. The AS test-group's high means of errors in the *focused predicate* condition (see (77)) could be taken as the source of the observed interaction.

(77) Focus sensitive negation- Focused positions



A pairwise comparison of the three focus positions reveals significant performance difference between the three conditions only for the AS test-group that performed significantly worse in the *focused predicate* sentences in comparison with the *focused object* sentences (Predicate M=3.1 SD=0.68, Object M=1.1 SD=0.39, p=0.05) as well as with the *focused subject* sentences (Predicate M=3.1 SD=0.68, Subject M=0.9 SD=0.31, p=0.004).

[17] Based on Mauchly's test the assumption of sphericity has been violated ($\chi^2(2)=10.64$, p=0.005) therefore degreed of freedom where corrected using Huynh-Feldt estimates of sphericity (ε=0.78)

In order to validate these findings and in order to provide a reliable explanation for the obtained differences, further examination involving larger amounts of stimuli is needed. However, preliminary direction for explaining these differences might stem from the fact that obligatory accentuation of verbs is considered to be less frequent. Various works on focus distribution indicate that when the focus is broad, as in cases in which the entire IP or VP are focused (hence, "new", or "not given", in the discourse), the verb tend to be unaccented (see Schmerling 1974, Ladd 1980, Selkirk 1984, Schwarzschild 1999, Gussenhoven 2007, Krifka 2007 among others).

See for example the short dialogues in (78) and (79). Though the entire transitive VP in (78b) and (79b) corresponds to the WH element and forms "new" information in the context of the discourse, accent is realized on an internal argument while the head of the VP is unaccented.

(78) a. What did Greg do?
b. He washed the DOG

(79) a. What did Ruth do?
b. She saw a movie about DOGS

In (80), and (81) (from Gussenhoven 1992), though the entire IP is "new" in the context, the subject is accented while the predicate is not.

(80) a. What's this noise?
b. The DOG is barking.

(81) a. Where is the canary?
b. The CAT'S killed it.

The above prosodic patterns were found to be felicitous in experimental assessments based on priming effects, appropriateness judgments and sentence comprehension (Bishop 2012b, Birch and Clifton 1995) and its felicitousness was explained and predicted by various focus theories (e.g. Selkirk 1984, Schwarzschild 1999).

Focus projection theories for example (Selkirk 1984, Gussenhoven 1999), explain these focus patterns as the result of the application of focus projection rules. According to projection rules, accenting an internal argument of the verb (e.g the object) enables the projection of the focus feature (f-marking) to the verb; the head of the verb phrase. A focused head can project the focus feature to the phrase level (e.g.

the VP node) such that the entire VP could be interpreted as f-marked (see (78) repeated in (82)).

(82) a. What did Greg do?
b. He [[washed] $_F$ [the DOG] $_F$]$_F$

Thus, as long as there is an internal argument that bears pitch accent, focused VP will never require the verb itself to be accented. Accentuation of the verb, therefore, is generally required in cases of narrow focus, as in the answer to the question in (83), or in specific conversational contexts as in the contradiction in (84).

(83) a. What did Greg do with Ruth's car?
b. He [WASHED] $_F$ it
(84) a. Greg washed the car
b. No, he [PAINTED] $_F$ it

If the AS participants experience difficulties in interpreting focused structures, it could be that the frequency of focus patterns in the language will have prominent effect on their performance. This assumption might also account for the non-significant, though noticeable, difference in the control group performance in the *focused predicate* sentences (76). However, in order to provide a more solid explanation, this assumption regarding frequency effects should be further examined and evaluated in future research.

6.4.2. *Focus – suitable answer judgment task – group analysis*

Table (85) presents the results of the *suitable answer judgment task* according to the different conditions that were examined – semantic and prosodic *match* (85a), *prosodic mismatch* (85b) and *semantic mismatch* (85c). As it is obvious from the results, the *prosodic mismatch* question-answer pairs (85b) was the only condition in which the AS test-group misjudged unsuitable answers to be suitable responses. In the majority of the prosodically mismatched question-answer pairs (117 cases out of a total of 162, 72%), the AS test-group participants accepted an answer in which the focused constituent was not compatible with the Wh-element in the question, as an appropriate and suitable answer to the question.

The AS test-group differ significantly from control group in their performance in the *prosodic mismatch* condition ($U=14.5$, $p<0.001$) whereas no significant

differences between the groups were detected in the two other conditions (*Match*, U=85.5, p=0.7, *Semantic mismatch*, U=90, p=0.86). Nevertheless, it is important to note that in the present task, the control group participants also made relatively large amount of judgment errors when they judged prosodically mismatched answers to be suitable responses in 51 cases out of a total of 378 (13.5%).

(85) Focus – suitable answer judgment task - group analysis

	Sentence type	***AS test group*** *(n=9)*		***Control group*** *(n=21)*	
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***
a.	Match	**0.0%** *(0.0)*	0/81	**1.1%** *(3.3)*	2/189
b.	Prosodic mismatch	**72.0%**** *(33.6)*	117/162	**13.5%** *(23.9)*	51/378
c.	Semantic mismatch	**0.0%** *(0.0)*	0/81	**0.5%** *(2.4)*	1/189

*p<0.05, **p<0.01

Close examination of the control group performance reveals that only 6 participants, out of the 21 who took part in this task as a control group, were responsible for the vast majority of these misjudgments, since they judged almost systematically prosodically mismatched answers as suitable for the question. It should also be noted that two other control participants that consistently judged prosodically mismatched answers as correct responses were deliberately excluded from the analysis of this task's results. After completing the task, these two participants have announced that *"intonation"* made it difficult for them to choose the *"right"* answer. One of these participants stated his feeling in the following words: *"the intonation killed me but I succeeded anyway. I have managed to fight it!"*. Their statements, taken together with their decision pattern, indicated that their judgment was not intuitive but rather a result of a conscious and deliberate thinking. Therefore, they were excluded from the control group.

Table (86) presents the *suitable answer judgment task* results according to the division of the control group to the two sub-groups of fifteen and six participants, based on behavior pattern. These two sub-groups were found to be significantly

different in terms of accuracy (U=0, p<0.001), due to the fact that the sub-group of 6 participants judged almost half of the prosodically mismatched answers as appropriate responses. This sub-division is also supported by reaction time analysis (see §7 for details) as the sub-group of six responded was slower in their reaction in comparison with their control peers.

(86) Focus - suitable answer judgment task - control subgroups

		AS test-group		***Control group***			
				Sub-group 1 15 participants		***Sub-group 2 6 participants***	
	Sentence type	***% error (SD)***	***No. error***	***% error (SD)***	***No. error***	***% error (SD)***	***No. error***
a.	Match	**0.0%** *(0.0)*	0/81	**0.7%** *(2.8)*	1/135	**1.9%** *(4.1)*	1/54
b.	Prosodic mismatch	**72.0%**** *(33.6)*	117/162	**0.7%** *(1.9)*	2/270	**45.4%** *(23.9)*	49/108
c.	Semantic mismatch	**0.0%** *(0.0)*	0/81	**0.0%** *(0.0)*	0/135	**1.9%** *(4.1)*	1/54

**p<0.01

However, in spite of the relatively high percentage of errors made by control subgroup of 6 participants, the performance of the AS test-group in the *prosodic mismatch* condition was worse than that of both control subgroups[18].

The pattern of the AS test-group response in this task might reflect a limited and narrower processing of lexical-semantic relationships, a pattern which was argued to characterize the processing of unfocused information (Sanford and Garrod 1998, Sanford and Sturt 2002, Bishop 2012b). See section 10.3.3 for further discussion.

[18] Suitable answer judgment task: prosodic mismatch condition:
A comparison of the AS test-group and control sub-group 1 (15 participants). Comparison *per subject*: U=0, p<0.001. Comparison *per item:* U=0, p<0.001.
A comparison of the AS test-group and control sub-group 2 (6 participants). Comparison *per subject*: U=14.5, p=0.16. Comparison *per item:* U=5, p<0.001.

6.4.3. *Focus - suitable answer picture-matching - group analysis*

The *suitable answer picture-matching* task was designed to evaluate reaction times, based on the assumption that sensitivity to prosodic cues might slow the response of the control group in cases of prosodically mismatched question-answer pairs. Reaction times analysis will be detailed in section 7.

In terms of accuracy, the participants of both the AS test-group and the control group were expected to have no difficulty in choosing the correct picture for both conditions, due to the fact that in every trial there was only one picture which was semantically compatible with the question-answer stimulus, while the other picture was completely wrong (see 6.3.3 for examples). Table (87) presents the accuracy results of this task.

(87) Focus - suitable answer picture-matching - group analysis

	Sentence type	***AS test group*** *(n=9)*		***Control group*** *(n=22)*	
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***
a.	Match	**1.1%** *(3.1)*	1/90	**2.7%** *(6.9)*	6/220
b.	Prosodic mismatch	**0.8%** *(2.2)*	1/126	**4.2%** *(6.3)*	13/308

*p<0.05, **p<0.01

In a comparison *per subject*, no significant differences were evident in the performance of the AS test-group and the control in the two conditions - *Match* and *Prosodic mismatch* (U=95, p=0.89, U=72, p=0.25 respectively). However, it should be noted that the control group made relatively more errors than the AS test-group, and chose the wrong picture even in some cases of a match. This difference was in fact significant in a comparison *per item.* In this respect, the control group performance was found to be significantly worse than that of the AS test-group in the *prosodic mismatch* condition (U=41, p=0.009) as well as in task in general (U=141, p=0.003). It should also be added that within the AS test-group only two participants made one error each, while in the control group there was a total of 19 errors made by 9 different participants. Hence, almost half of the control participants made at least one picture matching error, in a task in which no errors were expected at all.

Given that the current task was the only task in which the control group made systematically more errors than the AS test-group, this task's results, despite their limitations, might still express some influence of the prosodic manipulation upon the

control participants and reflect the participants' expectations regarding prototypical prosodic patterns and regarding focus influence on information structure (Foss and Ross 1983, Bishop 2012a).

These assumptions are compatible with the findings of Bishop's (2012b) priming tasks. According to Bishop's findings in comparison with typical individuals, autistic-like individuals (i.e. non-autistic individuals that show high 'autistic traits' and poor communication skills) demonstrate more reliable semantic priming of targets, regardless of other, sometimes intervening, factors, including prosody. Bishop indicates that the response pattern of his less communicative, autistic-like, participants resembled the stronger and more stable priming effects found in earlier priming studies such as Tabossi's (1988) and Norris et al. (2006), in which prime words were presented in isolation rather than in the context of an utterance. The autistic-like participants' responses in Bishop's study were in general less affected by prosodic manipulations of accent placement, than the responses of participants that showed good communication skills.

Though not significant, the trend found in the accuracy results of the present task might suggest that task's requirements were more challenging for the control group participants, which anticipated prosodic pattern to directly affect their response, than for the AS test-group participants who were less sensitive to the prosodic manipulation.

6.5. Prosodic affect comprehension tasks – task description

The affect comprehension section of the PROSA battery included tasks which involved emotional speech. This condition was assessed in a judgment task for sentence-level and word-level.

6.5.1. ***Positive - Negative affect judgment (comprehension task):*** In this task the participants heard a sentence or a word and were asked to decide whether the speaker was happy/contented, or unhappy/discontented. The sentence stimuli in this task were emotionally neutral, hence, it did not contain words that reflect emotion explicitly and it did not describe situations which are emotional in nature. Therefore, these sentences could be interpreted as bearing positive or negative meaning based solely on the intonation in which it was uttered (88). The sentence-level part of this task contained

22 sentences, 12 of which were uttered in a happy, contented manner and 10 were uttered in a discontented, unhappy manner.

(88) Positive-Negative affect judgment– sentence level

a. kibalti ʃmonim ba-mivxan be-anglit ☺

'I got an 80 on my English test'

b. kibalti ʃmonim ba-mivxan be-anglit ☹

'I got an 80 on my English test'

While for some people getting an 80 or a B on a test would be considered a success, for others, the same score might cause a disappointment. Therefore, this sentence could be interpreted as bearing positive or negative meaning with dependence on the prosodic manner in which it was uttered.

The word level part of the affect judgment task contained 17 Hebrew forenames (89) that were uttered in a positive or a negative affect, 9 of which were uttered in a happy, contented manner and 8 were uttered in a discontented, unhappy manner.

(89) Positive-Negative Affect judgment – word level

a. Amálya ‘*Amalya*’ ☺

b. Amálya ‘*Amalya’* ☹

It should be noted that this task did not involve any visual aspects, i.e. it did not contain any pictures or images to represent the emotion that was conveyed in speech. This facet is vital since the autistic and the AS populations tend to exhibit notable deficits in recognizing bodily expressions of emotions (Weeks and Hobson 1987, Hobson et al. 1988) and demonstrate perceptual abnormalities in their ability to interpret emotion expressions in faces (Tantam et al. 1989, Hall et al. 2003, Dawson et al. 2005). Therefore, this task did not incorporate any visual aids, in order to ensure that the participants' response is based exclusively on the auditory stimuli and that it is free of any possible visual biases.

6.6. Prosodic affect comprehension tasks – group analysis

Table (90) presents the group results analysis of the affect comprehension tasks.

(90) Positive affect vs. Negative affect – group analysis

	Affect tasks	***AS test group*** *(n=9)*		***Control group***		
		% error *(SD)*	***No. error***	***% error*** *(SD)*	***No. error***	***n***
a.	Positive/Negative affect: *sentence level*	**1.0%** *(1.9)*	2/198	**0.2%** *(0.9)*	1/506	n=23
b.	Positive/Negative affect: *word level*	**3.9%** *(7.3)*	6/153	**0.5%** *(1.7)*	2/391	n=23

*p<0.05, **p<0.01

As evident from the figures above, the group analysis of the affect tasks does not reflect significant differences between the two research groups.

6.7. Interim summary – PROSA comprehension tasks – group analysis

The *comprehension tasks'* analysis confirms and refines the trend that was found in the *discrimination tasks* results, and thus allow to conclude that the most prominent and consistent difficulty of the AS test-group is reflected in the *pragmatic – focus tasks* (with a group average of up to 72% errors in some of the target conditions). The nature of the AS group's difficulty and its possible causes will be discussed in §10. No noticeable differences were evident in any of the *grammatical* or *affect tasks*.

The results of the *comprehension tasks* also support the findings regarding the pronounced variance that was evident in the AS group in the discrimination tasks (§5). The observed difficulty of the AS test-group in the *focus tasks* was in fact the result of the poor performance of *most* but not *all* the participants in the AS test-group (7 out of 9 participants). This aspect of *within-group* differences will be discussed in the *individual analysis* in §8.

Furthermore, the *comprehension tasks'* analysis highlights several questions regarding group behavior. The first refers to the AS participants' difficulty in comprehending sentences with a focused *predicate* vs. sentences with focused *subject* or focused *object*. The second question regards possible causes for the relatively high amount of errors made by control participants in the *focus - suitable answer picture*

matching task. These questions were addressed in this section based on preliminary suggestions; however, further research is required in order verify these finding and in order to provide more comprehensive accounts for these obtained trends

7. PROSA results – Reaction time analysis

In order to provide more adequate and comprehensive picture of the participants' performance, reaction time (RT) was collected and measured for all PROSA battery comprehension tasks.

The following sections address some issues regarding group differences in terms of reaction times (§7.1) and regarding the effect of task's conditions on participants' response time (§7.2).

7.1. Between subject variables – the effect of group

The reaction time comparison in (91) below reveals a clear and significant trend by which the AS test-group responds slower than control. This difference is fundamental as it was found in most tasks regardless of accuracy rates. That is, the AS test-group responded slower than control in tasks in which there was no significant difference between the two groups in terms of accuracy (e.g. *grammatical* (91a-d) and *affect tasks* (91h-i)) as well as in tasks in which a significant difference was evident (*focus – pragmatic tasks* (91e-g)). Therefore, it must be concluded that this observed disparity could not serve as indication for any sort of difficulty demonstrated by the AS participants but should be regarded as a fundamental characteristic of the AS test-group in this study.

The reaction time trend was found to be consistent in all but one task, the *Focus – suitable answer judgment task* that was described in §6.3.2 and analyzed in §6.4.2. In this task (91f), the reaction time trend was not only reduced but actually reversed in that the control group was relatively slower than the AS test-group.

(91) PROSA Comprehension tasks - Reaction time (RT)

	Sentence type	***AS Average RT***	***Control Average RT***	***Sig.***
a.	Lexical Stress	1914	1290	$p = 0.008$
b.	Syntactic phrasing	2994	2117	$p = 0.016$
c.	Q-S word level	727	383	$p = 0.002$
d.	Q-S sentence level	744	436	$p = 0.010$
e.	Focus sensitive negation	5217	4074	$p = 0.006$
f.	**Focus – suitable answer judgment**	**822**	**950**	$\boldsymbol{p = 0.613}$
g.	Focus – suitable answer picture matching	3171	2262	$p = 0.007$
h.	Affect – word level	850	539	$p = 0.008$
i.	Affect – sentence level	746	508	$p = 0.091$

The difference between the AS test-group and the control group was obviously not significant in this task (p=0.613), however, since the accuracy analysis of the *Focus – suitable answer judgment task* indicated unusual pattern of behavior within the control group, it was of an interest to further examine the control group's performance in this task, in terms of reaction times.

As indicated in section §6.4.2, the control group participants made relatively large amount of misjudgments in this task when judging prosodically mismatched answers to be suitable responses for questions in question-answer pairs. However, these misjudgments were made almost exclusively by 6 individuals out of the 22 control participants that took part in this task ((86) revised here as (92)).

The two control sub-groups were found to be significantly different in terms of accuracy in their performance in the *prosodic mismatch* condition (p<0.001) as well as in their general performance in this task (all three conditions combined, p<0.001)

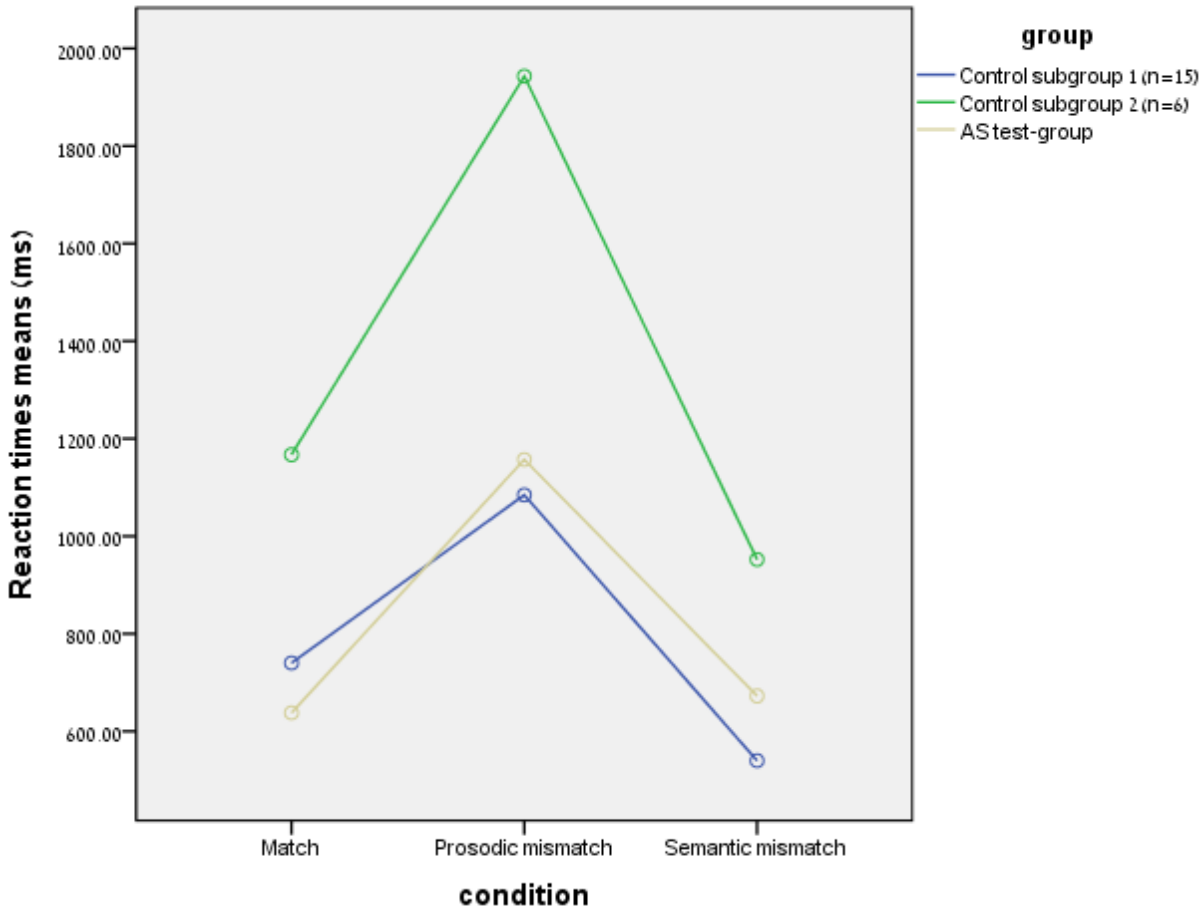
(92) Focus – suitable answer judgment task – AS test-group vs. control subgroups

	Sentence type	***Control group*** ***% error (SD)***	
		Sub-group 1 ***15 participants***	***Sub-group 2*** ***6 participants***
a.	Match	**0.7%** *(2.8)*	**1.9%** *(4.1)*
b.	Prosodic mismatch	**0.7%** *(1.9)*	**45.4%** *(23.9)*
c.	Semantic mismatch	**0.0%** *(0.0)*	**1.9%** *(4.1)*

*p<0.05, **p<0.01

In a comparison of the three groups in terms of reaction times, no significant differences were found between the AS test-group and the control subgroup of 15 participants (subgroup 1). However, the subgroup of six control individuals (subgroup 2) responded significantly slower than their control group peers (p=0.044) and relatively slower than their peers in the AS test-group (p=0.081) in the prosodic mismatch condition and in the test in general.

(93) Focus – suitable answer judgment task – comparison of reaction times means



In order to validate these differences, reaction times of control subgroup 2 (six participants) were compared to those of control sub-group 1 (fifteen participants) and to those of AS test-group, in other comprehension tasks. This additional analysis indicates that control subgroup 2 tended to respond relatively slower than control subgroup 1, however these differences were not significant in the other tasks. In addition, there was no other task in which control subgroup 2 was either relatively or significantly slower than the AS test-group. Hence, in all other comprehension tasks the two control sub-groups reacted faster than the AS test-group.

The *Focus – suitable answer judgment task* was a unique task within the PROSA battery in that it was a meta-lingual judgment task. The prosodically mismatched answers were semantically valid and therefore could be judged as suitable answers in semantic terms. However, due to the prosodic mismatch these answers were pragmatically infelicitous and therefore were expected to be judged as unsuitable. The participants in this task, as in all other PROSA tasks, were instructed to respond as

fast and as intuitively as possible. Despite the fact that the AS test-group and control subgroup 1 showed opposite patterns of response in terms of accuracy, the performance of these two groups in terms of reaction times seems to be consistent with their performance in other tasks and therefore could be considered as a natural intuitive reaction. Control subgroup 2 systematically judged prosodically mismatched stimuli as suitable answer in a question-answer pair and was found to be significantly different from the rest of the control group in terms of accuracy in the *Focus – suitable answer judgment task*. The irregular reaction times pattern that was found in this task for subgroup 2 might therefore suggest that these six participants might have used a more cautious strategy and invested considerable effort in making a conscious logical decision that was not based on mere intuition. The reaction time investigation strengthens therefore a line of analysis that separate the six participants of control subgroup 2 from their control peers and refer to control subgroup 1 as the more reliable comparison group in this specific task.

In the following discussion regarding within-subject factors, I therefore refer to subgroup 2 as control group in the context of the current task.

7.2. Within subject variables – the effect of condition

Another aspect that arises from the above results concerns the possible influence of task's conditions (*Match / Prosodic mismatch / Semantic mismatch*) on reaction times within the different groups.

The *Focus – suitable answer picture matching task* described in §6.3.3 and analyzed in §6.4.3 was designed to evaluate reaction times, under the assumption that prosodic mismatches might have a slowing effect on individuals who perform normal prosodic abilities. However, the reaction time analysis of both control group and AS test-group revealed no significant differences between *Match* condition and *Prosodic mismatch* condition (p=0.173 for AS test-group and p=0.921 for control group). It should be noted however that control participants made a relatively large number of errors in the *Focus – suitable answer picture matching task* in comparison with their performance in other types of tasks and in comparison with the AS test-group in the task in question (see (87)).

Unlike in the *Focus – suitable answer picture matching task*, an analysis of condition influence on reaction times in the *Focus – suitable answer judgment task* reveals a different picture.

The graph in (91) shows clearly that all groups responded slower in the prosodic mismatch condition. However, the effect of condition was found to be significant for the control group (subgroup 2) but not for the AS test-group. The difference in reaction times between the *Match* condition and the *Semantic mismatch* condition was not significant for both AS test-group and control group (p=0.999, p=106 respectively), however, the difference in reaction times between the *Match* condition and the *Prosodic mismatch* condition as well as the difference between the *Semantic mismatch* condition and the *Prosodic mismatch* condition were found to be significant for the control group (p=0.042, p<0.001 respectively) but not for the AS test-group (p=0.292 p=0.369 respectively). It seems therefore that the response time of the control group was in fact more prone to be affected by prosodic manipulations than that of the AS test-group. This datum might indicate a higher sensitivity of the control group to prosodic information, however, since this effect was found in the *Focus – suitable answer judgment task* but not in the *Focus – suitable answer picture matching task* further research is needed in order to verify these findings and in order to achieve a more comprehensive picture regarding the effect of prosodic manipulation on response time amongst these different groups.

8. PROSA results - Individual analysis

The following table (94) displays the individual scores of the AS participants in the PROSA battery tasks. Figures in this table indicate the percentage of errors in target items, made by each of the AS participants in every PROSA battery task. This analysis is based on Crawford-Howell *t*-test for case-control comparisons (1998) that enables to compare between an individual test score (a single case), and a small group of control scores. For each task, the Crawford-Howell *t*-test estimates the highest percentage of errors that is still within the normative range, therefore, the threshold value for significance differs across tasks.

Each column in (94) specifies the results of a different participant in the AS test-group, and each row refers to a different PROSA task. Figures in this table that appear in red signify that the percentage of errors made by the relevant participant in the specific task was significantly higher than the normative percentage of errors in that task (p<0.05). For example, the percentage of errors made by *participant 8* in the *lexical stress discrimination task* (28.1%, first row, right column) was significantly higher than the norm percentage of errors in this task.

(94) AS Individual results – percentage of errors in PROSA tasks (%)

Subgroup	(a)		(b)				(c)			
Task / Participant	1	3	2	6	7	9	10	4	5	8
Lexical stress *Discrimination task (32 items)*	0	0	0	0	0	3.1	3.1	0	0	**28.1**
Lexical stress *Comprehension task (16 items)*	0	0	0	0	0	0	0	0	0	**12.5**
Syntactic phrasing *Discrimination task (40 items)*	5.0	0	5.0	7.5	2.5	0	5.0	5.0	**10.0**	**50.0**
Syntactic phrasing *Comprehension task (23 items)*	0	0	0	4.3	4.3	0	4.3	**13.0**	4.3	**34.8**
Q-S – word level *Discrimination task (18 items)*	**5.6**	0	0	0	0	0	**38.9**	**16.7**	**5.6**	**22.2**
Q-S – word level *Comprehension task (18 items)*	0	0	0	0	0	0	**11.1**	0	**11.1**	0
Q-S – sentence level *Discrimination task (20 items)*	5.0	0	0	0	0	5.0	**15.0**	0	5.0	**30.0**
Q-S – sentence level *Comprehension task (18 items)*	0	0	0	0	0	0	0	0	**5.6**	**11.1**
Contrastive focus *Discrimination task (20 items)*	0	**10.0**	**10.0**	**20.0**	**5.0**	0	**55.0**	**35.0**	0	**65.0**
Focus sensitive negation *Comprehension task (18 items)*	0	0	**55.6**	**33.3**	**38.9**	**27.8**	**22.2**	**33.3**	**44.4**	**100**
Focus - suitable answer judgment *Comprehension task (36 items)*	0	0	**33.3**	**50.0**	**47.2**	**50.0**	**47.2**	**50.0**	**33.3**	**44.4**
Affect – word level *Discrimination task (17 items)*	0	0	0	0	0	0	**11.8**	**17.6**	**17.6**	**23.5**
Affect – word level *Comprehension task (17 items)*	0	0	0	**5.9**	0	0	**5.9**	0	**23.5**	**5.9**
Affect – sentence level *Discrimination task (22 items)*	0	0	0	0	**9.1**	0	**27.3**	**13.6**	**13.6**	**27.3**
Affect – sentence level *Comprehension task (22 items)*	0	0	0	0	0	0	**4.5**	**4.5**	0	**4.5**

$p < 0.05$

It should be noted that the arrangement of participants' results in the above table is based on their error pattern (rather than on their serial number). It seems that even though the AS test group comprises of rather small sample of participants, several subgroups could be detected (division into subgroups is indicated by a yellow line).

The first subgroup, (a), includes the participants in the two left columns – participants 1 and 3. These participants demonstrated control-like behavior throughout the study and neither of them showed systematic difficulty in identifying and interpreting the prosodic information in any of the study's conditions.

Another subgroup, (c), includes the participants in the four right columns of the table - participants 10, 4, 5 and 8. These participants demonstrated difficulties in various tasks that involved syntactic, pragmatic and emotive uses of prosody. However, it should be noted that this is not a homogenous group.

The last subgroup, (b), comprises of participants 2, 6, 7 and 9 in the middle columns of the above table, who showed a selective difficulty in *focus* tasks.

This division specifies two subgroups that exhibit regular difficulties in prosodic tasks (b) and (c), with a shared deficiency in focus perception. A broader analysis that consider comorbidity, verbal skills and observable correlations between prosodic abilities and other linguistic and cognitive skills (95), could account, to some extent, for the differences between these subgroups.

(95) Individual results - Summary

Participant		Comorbidity	Verbal IQ	The PROSA battery					ToM	W.M	Syn.	Lex.	Read.	Prag.
				Lexical stress	Syn. phras.	Q-S	Focus	Affect						
(a)	1	OCD, Schizophrenia	99											
	3	ADHD	116											
(b)	2	Anxiety disorder	113				■							
	6	Not reported	110				■							
	7	Anxiety disorder	99				■							
	9	Not reported	113				■							
(c)	10	Not reported	113			■	■	■						
	4	Not reported	87		■	■	■	■		■	■	■		
	5	Learning dis.	113		■	■	■	■			■	■		
	8	Learning dis., ADHD	80*	■	■	■	■	■		■	■		■	

■ = Significant difference $p < 0.05$

Syn. phras.=Syntactic phrasing, W.M=Working memory, Syn.=Syntactic abilities, Lex.=Lexical retrieval, Read=Reading skills, Prag.=Pragmatic competence

* 80 is considered the lowest verbal IQ score within the norm. It is classified as borderline mental functioning (vIQ: mean=100, SD=15)

The four participants in subgroup (c) were the only AS participants who demonstrated systematic difficulty in the affect tasks and in the Q-S tasks. In addition, most of the participants in this subgroup, with the exception of participant 10, exhibited linguistic and cognitive difficulties that might have affected their performance in the prosodic tasks.

As revealed by the general *linguistic skills evaluation*, all three participants, 4, 5 and 8, demonstrate imperfect syntactic skills and differed from control in their ability to repeat and produce complex syntactic structures. Participants 4 and 5 also exhibited impaired lexical retrieval abilities.

Participants 4 and 8 share a deficit in phonological working memory. These difficulties are also manifested in their general verbal IQ score. They both received the lowest verbal IQ scores amongst the AS participants (87 and 80 respectively), and they are the only participants in the AS group that scored below the normative vIQ mean score of a 100 points. According to Cohen (1989), working memory is an essential tool for integrating information of different sources. It could be then that the need to integrate and interpret prosodic material in addition to formal structural information forms greater challenge for these participants than to their AS peers. Another feature that might support this assumption arises from comparing accuracy rates of the two distinct task modes – discrimination and comprehension. Verbal working memory deficiency is expected to yield length and complexity effects, hence, the expected outcome would be greater difficulty in those stimuli which pose grater cognitive load. Based on this reasoning, discrimination tasks should have been more difficult than comprehension tasks due to the need to hold in memory and compare two consecutive stimuli. This trend was in fact notable in the performance of subgroup (c) in the *affect* and the *Q-S* tasks; however, it was particularly prominent in the error pattern of participant 8.

Additionally, two participants, 5 and 8, reported on being diagnosed with learning disabilities. Comorbidity with Attention Deficit Hyperactivity Disorder (ADHD), Depression, Anxiety, Obsessive-Compulsive Disorder (OCD) and Schizophrenia is very common among individuals with AS. According to Gillberg and Billstedt's (2000) review, the probability of an individual with AS to be diagnosed with additional disorders is much higher than the likelihood of being diagnosed with AS alone.

However, despite similarities in error pattern, it should be emphasized that subgroup (c) does not form a homogenous group.

As mentioned in the *group analysis* sections (§5-§7), participant 8 was in fact excluded from the group analysis of the results due to unusual performance. His error pattern was exceptional in quantity and in quality of errors. For example, he was the only participant who failed the *lexical stress tasks* and misjudged almost 30% of the stimuli in the *lexical stress discrimination task*. His scores in the *syntactic phrasing* tasks were significantly worse than his AS peers and in the *association with focus - negation task*, he was the only participant who systematically chose the picture that was semantically inappropriate as the compatible picture for the target stimuli.

Participant 10 is unique in that she is the only participant in subgroup (c) who was not diagnosed with any additional deficiencies other than the observed prosodic difficulty. She is also the only participant in this subgroup that did not score lower than control in any of the pure grammatical tasks - *syntactic phrasing* and *lexical stress* tasks. Her malperformance in the prosodic battery is limited therefore to *focus*, *affect* and *Q-S* stimuli. This performance pattern highlights the need to address the unique characteristics of interrogative and declarative utterances. The prosodic contrast between interrogatives and declaratives is manifested by a semantic change of truth conditions and therefore was accounted as grammatical. However, unlike other stimuli in the grammatical section of the PROSA battery (*syntactic phrasing* stimuli and *lexical stress* stimuli) interrogatives diverse from declaratives in their conversational functions and therefore contrast in pragmatic aspects as well (this issue will be further discussed in §11). Approaching the performance pattern of participant 10 from this perspective might indicate a difficulty limited to pragmatic operations and affective uses of prosody. Additional evaluation of the performance of participant 10 is required in order to further assess these assumptions.

The above findings regarding the differences between the AS subgroups could strengthen Norbury (2005) claim that verbal abilities and structural language skills play central role in the comprehension of non-literal language. Norbury does not refer specifically to prosodic information; rather, her suggestions rely on the study of inferential processing and context. However, it seems that similar correlations emerges in the present study and connect formal linguistic skills with the ability to integrate and interpret prosodic information in the process of constructing multilayered meaning. The findings of several other studies provide additional

support for this view. McCann et al. (2007) report that the pronounced prosodic difficulties demonstrated by autistic children in their study highly correlate with language abilities rather than with age. Their findings further reveal a lack of correlation between the prosodic deficit and pragmatic abilities (measured by the Children's Communicative Checklist, CCC, Bishop 1998).

Further study is required in order to clarify the connection between formal language impairments and prosodic difficulties. However, the common difficulty in *focus* perception that found to feature in the participants of subgroup (b), and was not limited to subgroup (c), could not be explained by correlations with other deficits and therefore should be further addressed.

The following sections, 9 and 10, elaborate and discuss this issue of focus perception deficiency.

9. Explaining the common difficulty in *Focus* perception

In order to account for the AS participants' malperformance in perceiving the prosodic aspect of focus, I consider in this section several routes which indicate that explanation within cognitive theories of autism (ToM hypothesis, §9.1), as well as explanation based on working memory shortages (§9.2) or on auditory-acoustic hypothesis of the autistic deficits (§9.3), cannot account for the selective deficit that emerges in the pragmatic – *focus* – tasks. I will conclude this discussion in §10 with some promising venues within a framework of pragmatic and semantic models that can serve as a base for an explanation of the AS test group's difficulty in the *focus* tasks.

9.1 Prosody and the ToM hypothesis

No evidence for correlation between prosodic impairments and ToM deficits

The dissociation between prosodic competence and ToM skills revealed in the present study allows addressing presuppositions and methodological tools that were applied in earlier studies on the interface of ToM and prosody in the autistic population.

Studies that address the issue of prosody perception in autism tend to accept as an established fact that their autistic participants suffer from some degree of ToM deficit (Rutherford et al. 2002, Peppé et al. 2007, McCann et al. 2007, Chevallier et al. 2011 among others). This assumption relies on a body of research that identifies a close link between autism spectrum disorders and selective ToM deficits (Baron-

Choen et al. 1985, Baron-Cohen 1989, 2000, Bowler 1992, Happé 1994). According to the ToM hypothesis (Baron-Choen et al. 1985, Baron-Cohen 1989), some of the behavioral symptoms of the autistic disorder stem from a cognitive deficit in the ability to identify and infer mental states of others. However, the degree and the distribution of the ToM deficits within the autistic population are still uncertain mainly due to methodological diversity. In most studies that involve ToM assessment as a part of the research protocol, at least some of the autistic participants passed the ToM tasks (Tager-Flusberg 2007). In other studies, ToM deficits were considered a fundamental characteristic of the examined autistic population, such that there was no actual assessment of the participants' ToM competence as a part of the research protocol (e.g. Peppé et al. 2007, McCann et al. 2007). These issues challenge the validity of the 'Theory of Mind hypothesis' that defines the cognitive deficit in autism as the "absence" of ToM skills.

Rutherford et al. (2002) and Golan et al. (2007) argue that difficulties in extracting mental states from auditory stimuli, demonstrated by the autistic participants in these two studies, are directly connected to a deficit in their ability to extract ToM inferences. McCann et al. (2007) further surmise that adopting a view which regards the use of prosody for affective and pragmatic purposes as a ToM skill could account for the high prevalence of prosodic deficits among high-functioning autistics and AS individuals, and explain the dissociation between impaired prosodic abilities and relatively normal linguistic skills (e.g. syntax and vocabulary). The authors elaborate this view by pointing out the possibility that other pragmatic uses of prosody, such as contrastive stress (*focus*), which was not evaluated in their study, might also be affected as a result of a ToM deficit.

The above studies tend to interpret the autistics' prosodic difficulties, both receptive and expressive, as an outcome of a deficit in the cognitive ability of ToM, which often features in the autistic population. Based on this assumed association Rutherford et al. (2002) and Golan et al. (2007) suggest that participants' failure to perceive the emotional aspect of prosody can be used as a sensitive and subtle high-level marker for ToM competence and that prosodic tests should serve as a diagnostic tool for identifying defected ToM abilities.

When considering these views in light of the current study, two main issues should be addressed: The first concerns the notable results of the present study, which indicate dissociation between the prosodic competence of the AS test-group and their

ToM skills. The second issue is methodological, concerning the need to assess ToM abilities as a part of the research protocol and the necessity to design independent ToM tests, which isolate ToM skills and minimize any use or dependency on other cognitive and linguistic abilities. This will allow establishing adequate conclusions regarding the interface of ToM skills and other linguistic and cognitive aspects, such as prosodic competence.

9.1.1. ***Dissociation between prosodic impairments and deficits in ToM:*** The AS test-group's performance in the current study indicates dissociation between prosodic competence and ToM skills.

As emerges from the results in sections 5-7, the AS test-group demonstrates shared difficulty in the pragmatic function of prosody which involves *focus* (repeated below).

(96) Group analysis – Pragmatic *focus* tasks

Pragmatic tasks	***AS test group (% error)***	***Control group (% error)***
Contrastive focus *Discrimination task*	**15%****	**0.5%**
Focus sensitive negation *Comprehension task*	**16.0%****	**0.7%**
Focus – suitable answer judgment *Comprehension task*	**36.1%****	**6.8%**

*p<0.05, **p<0.005

The individual analysis of affect tasks (repeated in (97)) reveals significant difficulties in these tasks for some of the participants (subjects 10, 4, 5 and 8 of subgroup (c)).

(97) Individual results – *Affect* tasks (% error)

Subgroup	(a)		(b)				(c)			
Task / Participant	1	3	2	6	7	9	10	4	5	8
Affect – word level *Discrimination task*	0	0	0	0	0	0	**11.8**	**17.6**	**17.6**	**23.5**
Affect – word level *Comprehension task*	0	0	0	**5.9**	0	0	**5.9**	0	**23.5**	**5.9**
Affect – sentence level *Discrimination task*	0	0	0	0	**9.1**	0	**27.3**	**13.6**	**13.6**	**27.3**
Affect – sentence level *Comprehension task*	0	0	0	0	0	0	**4.5**	**4.5**	0	**4.5**

* Results highlighted in red represent significant difference between the individual's performance and the control group's performance ($p<0.05$)

Crucially, the performance of the AS test-group in the aToMic battery shows no obvious indication for a ToM deficit (see §3.1-§3.2 for detailed description of tasks and results). All the AS test-group participants passed the classic ToM tasks (e.g. *first and second order false-believe tasks*) as well as the high, adult-level, tasks which are aimed to reveal ToM deficits in high functioning adult populations (e.g. *Instruction task, Knowledge Gaps, Faux Pas, Surprise,* and *emotional false believe task*) (Balaban 2010, Gross and Harris 1988, Happé 1994, Baron-Cohen et al. 1999, Stone et al. 1998).

In addition, the AS participants did not differ from control in their ability to derive the relevant implicatures in the *scalar implicature* task (see §3.5.4.2). Pijnacker et al. (2009) emphasize that the process of deriving scalar implicatures, as other conversational inferences, requires some degree of 'mindreading'. It relies on the participants' ability to reason about the speaker's knowledge and intentions and it involves the attribution of thoughts and beliefs to other people minds.

The above findings weaken the assumption that misperception of mental states, thoughts and feelings conveyed through speech directly reflects impaired ToM abilities. Consequently, an interpretation of the participants' prosodic performance in the context of ToM impairment might not be viable. Furthermore, if prosodic impairments could be relatively discrete from ToM abilities, as emerges from the

findings of the present study, recent suggestions which account prosodic tasks as a tool for ToM diagnosis should be reconsidered.

9.1.2. ***ToM assessment as a part of the research protocol:*** The literature of the past two decades widely agrees that ToM deficits are common among many autistic individuals and the results of the present study do not challenge this view. However, it is well established that the autistic individuals do not, by any means, form a homogenous group since the autistic phenomenon is a spectrum of disorders which could differ significantly in terms of expression and severity of symptoms. Therefore, any study that deals with the interface of ToM competence and other skills or abilities that feature in the autistic population, should take into consideration the likelihood that not all autistic individuals experience the same difficulties in understanding and representing thoughts, feelings and intentions of others. Therefore, in order to ground any assumptions regarding the interface of ToM skills and other linguistic and cognitive abilities, such as prosodic competence, a study that aims to address these notions should include a formal assessment of ToM abilities as a part of the research protocol.

9.2. Prosody and Working Memory

No evidence for correlation between prosodic impairment in focus perception and deficits in phonological working memory

Working memory is generally defined as the process by which information is temporary maintained in an activated state to guide behavior (Baddeley 1986). It is conventionally included under the umbrella of 'Executive Functions' together with planning, impulse control, inhibition and initiation and monitoring of action (Ozonoff 1997), among other cognitive abilities.

Earlier studies present conflicting evidence of impaired working memory in autism. Hughes et al. (1994) and Ozonoff and Jensen (1999) indicate that both low and high-functioning autistics perform worse than control on planning tasks which demand the use of working memory. Bennetto et al. (1996) assessed verbal working memory among high-functioning autistic individuals and found the autistics' group to be significantly poorer in their performance relative to control. In contrast, Russell et al. (1996) did not find significant differences between two groups of autistic individuals (children and adolescents) and matched control, in sentence-span task as well as in two other non-verbal tasks. Ozonoff and Strayer (2001) also did not find

any autism-specific deficiency in three tasks and five dependent measures of working memory that were investigated, providing further evidence for intact working memory in autism.

As in the latter studies, the results of the current study, which includes four standardized phonological working memory tasks (Friedmann and Gvion 2003, Gvion and Friedmann 2008) showed no significant group differences in working memory aspects that were investigated (FriGvi battery, sections 3.3-3.4).

It should be further emphasized that only two participants within the AS group (participants 4 and 8 of subgroup (c)) demonstrate systematic failure in the working memory evaluation tasks. None of the participants in subgroup (b), which demonstrate a selective difficulty in prosodic *focus tasks*, or in subgroup (a), which showed control-like performance in all study's tasks, was characterized by an impaired working memory.

A deficit in working memory is predicted to cause pronounced length and complexity effects such that stimuli which pose greater cognitive load are expected to be much more difficult. A pure working memory deficiency predicts, therefore, that sentence-level tasks should be harder than word-level tasks, that tasks with long sentences should reflect greater difficulty than tasks with short sentences, and particularly, that discrimination tasks should be more difficult than comprehension tasks as the former require to maintain and operate on two consecutive utterances. Hence, in terms of working memory abilities, discrimination tasks are comprised of longer and more complex stimuli. It requires repeated access to two distinct, yet very similar, utterances and it depends on reactivation of prosodic information from both utterances.

In order to assess these possible effects of impaired working memory, the following table (98) summarizes information regarding stimuli's relevant features.

As evident from (98), the *focus tasks*' stimuli were shorter or close in length to those used in the *syntactic tasks* and in some of the *Q-S* and *affect tasks*. It should also be noted that three out of four *focus tasks* comprised of only simple sentences, while the fourth task (*Association with focus – negation* task) contained sentences with a subordinated clause. Complex sentences, containing subordination as well as coordination of clauses, were also used in the syntactic phrasing discrimination task.

(98) Mean length of target stimuli

Task	Mean No. of syllables per stimuli (SD)	Mean No. of words per stimuli (SD)	Number of utterances
Lexical stress *Discrimination task*	4 (0.0)	2 (0.0)	2
Lexical stress *Comprehension task*	2 (0.0)	1 (0.0)	1
Syntactic phrasing *Discrimination task*	28.2 (5)	10.3 (1.1)	2
Syntactic phrasing *Comprehension task*	12.8 (1.8)	5 (0.0)	1
Q-S – word level *Discrimination task*	5.6 (1.1)	2 (0.0)	2
Q-S – word level *Comprehension task*	2.7 (0.6)	1 (0.0)	1
Q-S – sentence level *Discrimination task*	17.8 (1.5)	6 (0.0)	2
Q-S – sentence level *Comprehension task*	8.8 (0.8)	3 (0.0)	1
Contrastive focus *Discrimination task*	17.8 (1.5)	6 (0.0)	2
Focus sensitive negation *Comprehension task*	13.7 (2.4)	4.7 (0.4)	1
Focus - Suitable answer judgment *Comprehension task*	16.7 (1.9)	6 (0.2)	2
Focus - Suitable answer picture matching *Comprehension task*	17.7 (1.9)	6 (0.0)	2
Affect – word level *Discrimination task*	5.7 (1.0)	2 (0.0)	2
Affect – word level *Comprehension task*	2.8 (0.5)	1 (0.0)	1
Affect – sentence level *Discrimination task*	20.7 (3.8)	8 (1.3)	2
Affect – sentence level *Comprehension task*	10.4 (1.9)	4.1 (0.6)	1

Individual results analysis (detailed in (94)) reveals that three participants, (4, 8 and 10 of subgroup (c)), demonstrate response pattern that is compatible with the expected trend for working memory deficiency, showing higher rates of errors in discrimination tasks than in comprehension tasks throughout the PROSA battery (99). However, this

trend was either reversed or dramatically reduced in the pragmatic *focus* tasks (100). In addition, the average error rates of these three participants increased significantly in the focus tasks (both discrimination and comprehension).

These findings suggest that the substantial difficulty displayed by these three participants in the *focus* tasks, could not stem exclusively from a working memory deficiency and must reflect an additional, non-dependent, difficulty in focus perception.

(99) Error rates – discrimination vs. comprehension: ***Non focus tasks***
(Lexical stress, Syntactic phrasing, Q-S, Affect)

Participant	**Discrimination tasks** *(Average error rates %)*	**Comprehension tasks** *(Average error rates %)*
4	8.8	2.9
8	30.2	11.5
10	16.9	4.3

(100) Error rates – discrimination vs. comprehension: ***Focus tasks***

Participant	**Discrimination tasks** *(Average error rates %)*	**Comprehension tasks** *(Average error rates %)*
4	35.0	41.7
8	65.0	72.2
10	55.0	34.7

On the basis of the above findings it can be argued that verbal working memory impairment could not explain the selective difficulty displayed by subgroup (b) in the *focus tasks*, and it could not account for the higher error rates and for the change of trends in subgroup (c)'s performance in these tasks.

9.3. The prosodic deficit as a conceptual impairment in processing and representing phonetic information

No sufficient evidence to account for a selective deficit in focus perception

Another path that should be deliberated as a potential explanation for the participants' performance is a disorder at the acoustic sensory or perceptual levels, i.e. a deficiency in the ability to perceive the acoustic information manifested by pitch, duration and intensity. The findings regarding perceptual auditory alterations in autism are often

contradicting (§9.3.1), but since perceptive auditory disturbance has emerged as an autistic feature in various experimental studies, it should be considered as a possible source for the participants' difficulties. Section 9.3.2 evaluates the findings of the present study in light of a possible auditory/acoustic impairment and explains why this hypothesis cannot account for the AS test group selective deficit in *focus* perception for two main reasons. Primarily, due to the relative low amounts of errors made by some of the AS participants in the *Pragmatic discrimination task*, and secondly due to the fact that pitch changes, which are the main phonetic correlates of focused constituents (Halliday 1967, Ladd 1980, Pierrehumbert and Hirschberg 1990), feature in other prosodic contrasts (e.g. lexical stress contrasts, question-statement contrasts, emotional contrasts in speech) which the AS participants did not fail to perceive.

9.3.1. ***Literature reveals contradicting findings:*** Studies indicate various abnormalities in the autistics' ability to perceive and process auditory information. Sensorial modulation anomalies were also reported, emerging as both hypoacusis and hypercusis in different individual cases. Klin (1993) concludes that the autistic participants in his study of brainstem evoked-potentials suffered from peripheral hypoacusis. These finding were supported by other studies, which also reported reduced sensitivity to auditory input amongst the autistic population (Koegel and Screibman, 1976, Hayes and Gordon, 1977, among others). However, hypoacusis could not account for the entire auditory picture of the autistics since auditory heightened sensitivity was also reported as an autistic common feature (Gillberg and Coleman 2000, Rosenhall et al. 1999, Collet et al. 1993, Attwood 1998, among others).

An EEG study reported in Erwin et al. (1991) measured auditory event-related potentials (ERP) and concluded that the ability of 11 high-functioning autistic adults to perceive acoustic differences and discriminate between prosodic patterns was no different than that of control group participants. In this study, cognitive reaction to question-statement stimuli and to emotional happy-angry stimuli was measured using P3 potential (an ERP index for involuntary attention switch), and behavioral responses were assessed based on accuracy (pressing a button). Both methodologies showed remarkably normal reaction to the prosodic stimuli by the autistic group.

In contrary, in another neurophysiological study which evaluated a group of 8 Asperger participants, Kujala et al (2005) found that the Asperger group identified less accurately than the control (though not statistically significant), the emotional content of spoken words that were used as stimuli. In addition, the neural response of the Asperger group was abnormal in amplitude, topography and latency of MMN (MisMatch Negativity) component (an ERP index of sound discrimination), in comparison with the 8 control participants. Based on these results the authors concluded that the Asperger group was impaired in a low-level pre-attentive stage of auditory information processing. However, due to the characteristics of the stimuli in this study, which was normal speech and not a synthetic sample, the authors could not identify any specific feature of the stimulus to be the cause for the difficulty demonstrated by the Asperger group.

In an earlier ERP study that has involved synthetic stimuli, Jansson-Verkasalo and colleagues (2003) found that a group of 10 children with Asperger syndrome displayed abnormalities in transient encoding of acoustic sound features and in pre-attentive sound discrimination (MMN), in comparison with a control group of 11 children. It should be emphasized, however, that these deficits were more severe for non-speech stimuli (simple sinusoidal tones which differ in pitch) than for the speech stimuli (semi-synthetic Finnish CV syllables which differ in one consonantal phoneme). This study did not include prosodic stimuli.

In contrast, Čeponienė and colleagues (2003) found that children with autism were as able as controls to detect pitch alterations in both speech sounds (vowels) and non-speech sounds (simple and complex sinusoidal tone) as revealed by MMN response, but nonetheless these children showed no P3 response to a pitch alteration in vowels whilst demonstrating normal P3 response to a pitch change in non-speech tones suggesting that the autistic children could detect but not attend pitch changes in vowels.

The above studies display interesting, yet conflicting findings regarding abnormalities that feature in the autistic populations' neural processing of auditory stimulus. With regard to pitch perception some studies suggest that autistic individuals display pronounced difficulties (Kujala et al. 2005 among others), several others suggest the contrary arguing that autistic individuals outperform normal population in their pitch discrimination abilities (Mottron et al. 2006, among others), while others suggest that autistics do not differ from controls in their ability to detect

pitch deviations in both speech-sounds and non-speech sounds (Kemner et al. 1995, Gomot et al. 2002 among others). The picture is even less clear when it comes to receptive auditory and acoustic deficits that involve linguistic input with prosodic stimuli in particular. And yet, it should be taken under consideration that the processing of acoustic information and related decision making procedures could be disturbed, at least to some extent, for some of the autistic individuals.

9.3.2. ***Assessing the findings of the present study from a perspective of an auditory deficit:*** As I show in this section, an assumption which links the prosodic difficulty to any sort of sensory deficiency could not account for the common impairment in *focus* perception.

To begin with, an auditory sensory deficit should have yield higher rates of errors not only in tasks demanding meaningful interpretation of prosodic contrasts but also in those based on acoustic distinctions that are discriminative in nature. Hence, the relative low number of errors made by some of the AS participants in the *focus discrimination task*, in comparison with their performance in the *focus comprehension tasks* (see, in particular, subjects 9 and 5 below) cannot support an auditory deficit hypothesis as a satisfactory explanation for these findings.

(101) Individual results – Pragmatic *focus* tasks (% error)

Task \ **Participant**	**1**	**3**	**2**	**6**	**7**	**9**	**10**	**4**	**5**	**8**
Contrastive focus *Discrimination task*	0	**10.0**	**10.0**	**20.0**	**5.0**	0	**55.0**	**35.0**	0	**65.0**
Focus sensitive negation *Comprehension task*	0	0	**55.6**	**33.3**	**38.9**	**27.8**	**22.2**	**33.3**	**44.4**	**100**
Focus - suitable answer judgment *Comprehension task*	0	0	**33.3**	**50.0**	**47.2**	**50.0**	**47.2**	**50.0**	**33.3**	**44.4**

In addition, the most reliable acoustic correlate of focused constituents is *Pitch Accent*, local peaks in the F_0 contour, a high-frequency emphasis of prosodically prominent syllables. However, pitch changes are not an exclusive marker of focal elements and serve as one of the main acoustic cues in marking lexical word stress, in denoting prosodic units by assigning boundary tones (as in questions and statements)

and in indicating the emotional content of utterances (Halliday 1967, Ladd 1980, Pierrehumbert and Hirschberg 1990, Diehl et al. 2009).[19]

At least for some of the Asperger participants who failed the *focus* tasks, no significant malperformance was found in the *lexical stress* and *Q-S* tasks, or in the *affect tasks* (subjects 2, 6, 7, 9, subgroup (b)). These findings support the claim that the prosodic deficit displayed in this study cannot stem exclusively from a sensory, acoustic, deficit in auditory perception of pitch.

---

[19] It should be mentioned that both length and tone contrasts are not phonemic in Modern Hebrew and these two features serve as phonetic correlates of word stress (Cohen 2009, Adam and Bat-El 2009, Albert and Zaidenberg, 2009). Hence, when words are uttered in isolation their lexical stress is considered to be a combination of larger length and higher pitch. However, while vowel length directly marks stressed syllables, the tonal peaks do not always coincide with the perceived stressed syllable. High tone will be assigned to a stressed syllable when it is in phrase final position. Otherwise, tone-shift may take place and the high pitch will appear on the posttonic syllable (Becker 2003).

(102) Individual results – A selective difficulty in pragmatic *focus* tasks

Subgroup	(a)		(b)				(c)			
Participant / **Task**	1	3	2	6	7	9	10	4	5	8
Lexical stress *Discrimination task (32 items)*	0	0	0	0	0	3.1	3.1	0	0	28.1
Lexical stress *Comprehension task (16 items)*	0	0	0	0	0	0	0	0	0	12.5
Syntactic phrasing *Discrimination task (40 items)*	5.0	0	5.0	7.5	2.5	0	5.0	5.0	10.0	50.0
Syntactic phrasing *Comprehension task (23 items)*	0	0	0	4.3	4.3	0	4.3	13.0	4.3	34.8
Q-S – word level *Discrimination task (18 items)*	5.6	0	0	0	0	0	38.9	16.7	5.6	22.2
Q-S – word level *Comprehension task (18 items)*	0	0	0	0	0	0	11.1	0	11.1	0
Q-S – sentence level *Discrimination task (20 items)*	5.0	0	0	0	0	5.0	15.0	0	5.0	30.0
Q-S – sentence level *Comprehension task (18 items)*	0	0	0	0	0	0	0	0	5.6	11.1
Contrastive focus *Discrimination task (20 items)*	0	10.0	**10.0**	**20.0**	**5.0**	0	55.0	35.0	0	65.0
Focus sensitive negation *Comprehension task (18 items)*	0	0	**55.6**	**33.3**	**38.9**	**27.8**	22.2	33.3	44.4	100
Focus - Suitable answer judg. *Comprehension task (36 items)*	0	0	**33.3**	**50.0**	**47.2**	**50.0**	47.2	50.0	33.3	44.4
Affect – word level *Discrimination task (17 items)*	0	0	0	0	0	0	11.8	17.6	17.6	23.5
Affect – word level *Comprehension task (17 items)*	0	0	0	**5.9**	0	0	5.9	0	23.5	5.9
Affect – sentence level *Discrimination task (22 items)*	0	0	0	0	**9.1**	0	27.3	13.6	13.6	27.3
Affect – sentence level *Comprehension task (22 items)*	0	0	0	0	0	0	4.5	4.5	0	4.5

Nevertheless, due to the conflicting and inconclusive findings regarding the potential auditory perceptive disturbance in autism, future research should consider these open questions and possibly include a formal assessment of the auditory perceptual aspects

of prosody (i.e., the participants' ability to perceive modifications of pitch, duration and intensity), this in order to achieve a more adequate picture of the autistics' disabilities in performing prosodic tasks.

10. Explaining the common difficulty in focus perception: Pragmatic and semantic models as promising venues for explanation

As arises from §8-§9, the observed prosodic difficulty in focus perception, demonstrated by the AS test group, cannot be explained as stemming from a ToM deficit, it cannot be accounted as a direct effect of working memory deficiency and it could not be considered a pure auditory or acoustic phenomenon.

In the present section I address the AS test-groups' difficulty from a pragmatic and semantic point of view in attempt to define and localize the subjects' deficit. These lines of analysis, though preliminary, might shed some light on the selectiveness of the prosodic difficulty shared by the AS participants.

The definition of focus in the linguistic literature within the various theoretical approaches relies on a corpus of diverse and heterogeneous phenomena (e.g. sentences stress, quantifier scope and pronoun interpretation among other manifestations of focus). In §10.1 I provide a brief overview of some of the prominent focus theories in the literature addressing the aspects that are relevant for the discussion of the AS participants' pronounced difficulty from a semantic perspective. This section therefore covers only a handful of issues that occupy the vast literature and extensive research of the *focus* phenomenon.

The discussion of the AS test groups' deficit in §10.2 refers to the dual role of focused elements in both semantic and pragmatic inferences and to the prospect of using this duality in order to define the scope of the prosodic deficit shared by the AS participants. The analysis further elaborates two theoretical routes of inquiry. The first route refers to the theory of Alternative Semantics (Rooth 1985, 1992) and considers a possible impairment in semantic operations that underlie *focus* processing - the operation of generating alternatives that are induced by focused expressions (§10.3). The second route considers constraints which govern *focus* assignment (Schwarzschild 1999) and discusses the implications of a possible deficit in this constraint-based system on language comprehension (§10.4).

10.1. Approaches to focus: A brief overview

While there is some agreement in the linguistic literature regarding the range of pragmatic and semantic phenomena that are focus related, there is no general consensus about the definition of *focus* and about the exact nature of the pragmatic and semantic effects of *focus*.

On the pragmatic level, many views take *focus* to reflect information status. The phenomenon of *focus* is generally explained as a part of the relation between an utterance and the larger discourse. It has been suggested that the focus of a sentence stands for *the answer to the (explicit or implicit) question* presented in the discourse or that *focus* reflects (roughly) *"new"* vs. *"given"* information and taken to be the informative or more important part of the utterance, which cannot be inferred from the preceding discourse.

On the semantic level, it is well established that some linguistic expressions such as *only*, *also*, and *even* are focus-sensitive in that their meanings (in terms of truth conditions) are directly affected by the position of focus. However, the way in which these focus-sensitive particles are interpreted is debatable. Perhaps the most stable consensus on the issue of *focus* are the observation regarding an association between *focus* and prosodic prominence (pitch accent), and the shared intuition that focus enhances the saliency of a set of alternatives that are relevant for the interpretation of linguistic constituents. Yet, the procedures that determine how focus is *marked* and how it is *interpreted* are still under debate in the theoretical literature.

Two of the prominent approaches to *focus interpretation* that were proposed in the literature are *movement based* accounts (Chomsky 1976 and related work) and *in situ* accounts (Rooth 1985, 1992 and related work). According to *movement theories*, in order to be interpreted, a focused constituent moves from its original position to a position that is adjacent to that of a focus sensitive operator, leaving a trace behind. This covert movement in focus constructions is assumed to operate at the level of Logical Form (LF) and considered to be parallel to structures derived by Wh-movement. Focus movement approaches were undermined due to the fact that focus showed to be insensitive to syntactic islands. Hence, focus interpretation and representation that rely on movement yields systematic violations of syntactic constraints on movement, constraints that hold for other types of transformations (e.g. Wh-movement and Quantifier Raising).

These open issues have led to Rooth's (1985, 1992) *in situ* interpretation of focus constituents. Rooth's *Alternative Semantics* theory suggests that the semantic value of an expression containing focused constituent can vary. According to Rooth, expressions that contain focused constituents are assigned with two semantic denotations. The first denotation is the *ordinary semantic value* of the expression that is computed with no consideration of focus, hence, as if the expression has no focused constituents. The second denotation is the *focus semantic value* of the expression and it reflects the distinctive effect of focus on the meaning of the expression. The *focus semantic value* of a sentence evokes a set of contextually relevant alternative propositions that result from the substitution of the focused constituent. For instance, the *ordinary semantic value* of the sentence *[GREG]$_F$ loves Ruth* is (informally) the proposition that *'Greg loves Ruth'.* The *focus semantic value* of this sentence is the set of propositions of the form *'x loves Ruth'* which set an alternative individual in place of the focused constituent e.g. *{Linda loves Ruth, Paul loves Ruth, Aubrey loves Ruth}* (Rooth 1985, 1992, Wold 1996). Hence, according to Rooth's theory of focus, focused constituents contributes an additional semantic denotation to the expression by generating alternatives. It is assumed that these two levels of meaning are construed in parallel and that both levels constitute the semantic quantification domain of focus sensitive operators and affect pragmatic inference.

Following Jackendoff (1972) and Selkirk (1984), Rooth's focus interpretation theory relies on the assumption that focus is a property of syntactic constituents; hence, syntactic constituents are marked with a focus feature (*f*-marker) in the level of Surface Structure (SS). Given the organization of grammar in the *Extended Standard Theory* model (Chomsky and Lasnik 1977) Rooth assumes that the focus feature at the SS level interacts and correlates with phonology and phonetics (at PF level) and with semantic representation (at LF), coordinating prosodic manifestations and semantic/pragmatic interpretations of focus.

This assumption regarding an abstract syntactic marking of focus (*f*-feature) in the Surface Structure forms one of the basic assumptions of *focus assignment* theories such as Selkirk's focus *projections theory* (Selkirk 1984) and Schwarzschild's *constraint based theory* (1999). These theories are concerned with how and where *f*-marking occurs in the syntax and define the relation between accent placement and *f*-marking; a relation that results in an appropriate discourse and reflects information status (*novelty/givenness*).

According to Selkirk (1984) *f*-marking is determined by a set of *f*-assignment rules that are sensitive to syntactic relations:

(103) a. Basic *f*-rule: An accented word is f-marked

b. *f*-projection rules:

i. *f*-marking the head of a phrase licenses the *f*-marking of the phrase

ii. *f*-marking of an internal argument of a head licenses the *f*-marking of the head

iii. *f*-marking of the antecedent of a trace left by NP or Wh-movement licenses the *f*-marking of the trace

Based on this suggestion, word's accent can indicate its information status as well as the information status of larger phrases containing the accented word.

Schwarzschild (1999) criticizes some arbitrary and unmotivated generalizations in Selkirk's theory, such as the relation between information status and embedded *f*-marking (*f*-marked constituent within a larger *f*-marked phrase). Selkirk argues that embedded *f*-markers indicate *novelty* while unembedded *f*-markers may permit a *given* interpretation. According to Selkirk this generalization accounts for the fact that the direct object *[HIM]* in the answer to the question *who did John's mother praise? She praised [HIM]*$_F$ is accented though given in the context of the question. Schwarzschild rejects this claim and suggests that the connection between information status and accent placement in Selkirk's theory is unresolved. In addition Schwarzschild provides various examples that indicate Selkirk's theory's shortage in predicting the felicity of accent placement based on discourse's context as, for instance, in the case of accent pattern in sentences that are entirely given or in sentences in which a prenominal adjective (which according to Selkirk's suggestion cannot project focus) is accented. Schwarzschild's theory differs from Selkirk's in that it aims to account for discourse status by defining the notion of *givenness* and suggesting a semantic model according to which discourse *givennees* is calculable and determined via entailment relations of the utterance in question and the preceding context. Schwarzschild suggest an alternative account in which the correlation between *f*-marking and accent placement is conditioned by constraint ranking in an Optimality Theoretic grammar (Prince and Smolensky 1993). Schwarzschild introduces several constraints:

(104) Constraints on focus assignment (Schwarzschild 1999)

a. *GIVENNESS*: A constituent that is not *f*-marked is given

b. *AVOIDF*: Do not *f*-mark

c. *FOC:* A *foc*-marked phrase contains an accent[20]

d. *HEADARG:* A head is less prominent than its internal objects

(105) Ranking: *GIVENNESS, FOC* » *AVOIDF* » *HEADARG*

According to Schwarzschild, the interaction of these violable competing constraints in a system of ranked constraints can account for the distribution of focus and its effects on discourse appropriateness. Rather schematically, it could be argued that the interaction of *GIVENNESS* and *AVOIDF* enables the representation of information status via *f*-marking. The interaction of *FOC* and *AVOIDF* define the relation between *f*-marking and prosodic prominence, and the interaction of *AVOIDF* and *HEADARG* allows deaccenting and accounts for the head-argument asymmetry according to which not every unaccented head is *given* whereas unaccented arguments are inevitably *given*.

The following sections (10.3-10.4) address the AS test-group's difficulty in focus perception, in light of focus interpretation and focus assignment theories (Rooth's Alternative Semantics and Schwarzschild's constraint based approach respectively).

10.2. *Pragmatics* or *Focus*?

The dual role of focus as a tool in determining the scope of the prosodic deficit of the AS participants

Traditional views of the cognitive and linguistic deficit in autism suggest that while the development of formal syntactic and semantic aspects is relatively spared, pragmatic competence is impaired (see review in Loukusa and Moilanen 2009). These approaches are supported by variety of experimental data however in many cases they tend to be rather general and lack a systematic examination of parallel semantic and pragmatic operations. In addition, there are various studies, including the present one, indicating that the pragmatic deficit demonstrated in autism is selective in such way that not all aspects of pragmatic inferences are affected (Abramson 2012, Norbury

[20] "A FOC-marked node is an F-node that is not immediately dominated by another f-marked node", *Schwarzschild 1999, p.170*

2005, Pijnacker et al. 2009, Chevallier et al. 2010, Nieuwland et al. 2010, Bishop 2012b, see also section 4.5.4 for the AS test-group's results in the *scalar implicature* task and the *textual gaps* task).

The current section deliberates the possibility to use the phenomenon of association with focus as a toll for exploring and explaining the range of the observed prosodic deficit of the AS participants. The question that should be addressed is whether the AS test-group's capability to perceive and process focal accent when it serves a semantic role could be different or presumably better than their ability to use the same prosodic cues when it serves a pragmatic function.

The association of focused elements with a number of focus sensitive operators provides a window to explore both semantic and pragmatic operations. Semantic operators such as the negation operator, scalar additives like *even* and *also*, and exclusives such as *only* or *just* have different effects on the structure and meaning of the utterance. However, they all share the feature of sensitivity to focus, such that their interpretation depends on the placement of focal accent and intonational prominence within the sentence (Rooth 1992, Rooth, 1996, Hajičová et al. 1998, Beaver and Clark 2003). This phenomenon of association between semantic operators and focal elements leads to meaning-sensitivity to prosody that could have a direct effect on truth conditions and semantic meaning in some cases or might be perceived as a pragmatic phenomenon, influencing implicature computation and information structure in other cases (Rooth 1992, Krifka 2006). Should it be established that autistic individuals exhibit selective difficulty in drawing inferences from utterances in which focus induces a pragmatic change of information structure, in comparison with utterances in which focus induces a semantic change of truth conditions, the AS participant's difficulty, as emerges in the present study, might be explained as a pragmatic deficit in encoding and inferring prosodic information which does not reflect semantic contrasts. This sort of evidence could provide some support for those assuming dissociation between semantic and pragmatic ability in autism and some sort of autistic tolerance for pragmatic violations. However, findings that will point out difficulties in inferring both types of utterances will promote an assumption which regards the observed prosodic difficulties as reflecting a distinct deficit in focus related operations.

10.2.1. Association with focus and truth-conditional effects of focus:

The operator *only*, in (106) below, requires the constituent in its domain (ϕ) to be true and entails that every alternative for this constituent would not led to a true assertion:

(106) "*Only* ϕ" is true iff the proposition expressed by ϕ is the only true proposition in the set of alternatives to ϕ (Wold 1996)

According to *Alternative Semantics* (Rooth 1985, 1992), the *focus semantic value* of an utterance introduces the set of relevant alternative propositions that are generated based on the location of the focal accent. In the case of a sentence with the operator *only*, the *focus semantic value* of the sentence affects its truth value since in order for the sentence to be true, every alternative in the set of alternative propositions should be false. Hence, a change in the intonation pattern of the sentence will lead to a change in its truth conditions.

(107) Focus induces a change of truth conditions: the case of *only*

a. John only introduced Bill to $[\text{SUE}]_F$
b. John only introduced $[\text{BILL}]_F$ to Sue

Although both sentences in (107) assert the proposition that *'John introduced Bill to Sue'* as a part of their basic semantic meaning, due to the alteration of prosodic pattern, the two sentences entail different set of alternatives to be false, and therefore differ in their truth conditions.

The sentence in (107a) introduces a set of alternative propositions of the form *'John introduced Bill to x'* and in order for (107a) to be true every proposition in which *Bill* is being introduced to any addressee other than *Sue*, is required to be false. The sentence in (107b) introduces a different set of alternatives, of the form *'John introduced y to Sue'* and therefore requires that any proposition in which *Sue* is being introduced to any alternative addressee other than *Bill* should be false. Therefore, in a state of affairs in which *John introduces* <u>*Bill and Ruth*</u> *to Sue* and performs no other introductions, (107a) is true while (107b) is false whereas in a state of affairs in which *John introduces Bill to* <u>*Ruth and Sue*</u> and performs no other introductions, (107a) is false while (107b) is true.

Thus, the truth conditions of the two sentences in (107) alter as a result of focus position. The truthness of (107a) entails the falseness of propositions where the

focused indirect object is replaced with an alternative individual (e.g *'John introduced Bill to Greg', 'John introduced Bill to Ruth'...)* while the truthness of (107b) entails the falseness of a different set of propositions (e.g. '*John introduced Greg to Sue'*, '*John introduced Ruth to Sue'...*) in which the focused direct object is substituted.

10.2.2. Association with focus and pragmatic effects of focus

As opposed to the case of the operator *only*, in terms of meaning, the effect of association between the *negation* operator and the focus is pragmatic and does not influence truth conditions (Jackendoff 1972, Beaver and Clark 2008). When there is a focused phrase in the domain (ϕ) of the *negation* operator, the effect of association with focus could be generally stated as follows:

(108) "*Not* ϕ" asserts the falseness of ϕ (i.e. "*Not* ϕ" is true iff the proposition expressed by ϕ is false) and implies that there exists a true proposition in the set of alternatives to ϕ.

In the negation sentences in (109), despite the fact that the two sentences differ in their accent pattern, there is no alteration of their truth conditions. Hence, whatever the essential facts in the world are, either both sentences are true or both are false:

(109) Focus induces a change of information structure: *Negation*

a. It is not the case that John introduced Bill to $[\text{SUE}]_F$
b. It is not the case that John introduced $[\text{BILL}]_F$ to Sue

In terms of truth conditions, the two sentences in (109) are equivalent and their basic meaning does not vary as a consequence of alterations in focus position. Hence, in order for both sentences to be true, the proposition *'John introduced Bill to Sue'* should be false. However, a change in information structure between the two sentences does emerge and result in implying different set of alternative propositions to be potentially true. The implication arises from (109a) is that there is an alternative true proposition of the form *'John introduced Bill to x'* in which the indirect object – *Sue* is substituted. Hence, in the case of (109a) we surmise that there was in fact an occurrence in which John introduced *Bill* to *someone*, but not to *Sue*. The implication arises from (109b) is that there is an alternative true proposition of the form *'John introduced y to Sue'* in which the direct object – *Bill* is altered, hence, the sentence in

(109b) implies that there was an incidence in which John introduced *someone* to *Sue*, but it was not *Bill* that was introduced to her.

Contrary to the example with the operator *only* in (106), in which focus induced truth-conditional effect, in the context of the *negation* operator (109) a change in focus pattern has a pragmatic, non-truth-conditional, effect. The two sentences with *only* in (107) differ only in focus pattern and act as a minimal pair. The truthness of the statement in these sentences depends on the status of alternative propositions and therefore changes in focus position alter truth conditions and affect the truth values of the statements. The truth conditions of the *negation* sentences in (109), however, do not interact with alternatives and therefore a change in focus position does not affect the truth values of these sentences (see 108). Hence, regardless of changes in focus position, for every state of affairs both sentences in (109) are either true or false. The effect of association with focus in the sentence pair in (109) is manifested in the formation of different sets of potentially true alternatives for the negated propositions in (109a) and (109b), and should be referred to as a pragmatic change in information structure rather than a change in the construction of content.

Another conventional pragmatic use of focus is found in the correlation between the Wh-element of a question and the accented constituent of a corresponding answer:

(110) Pragmatic focus in question-answer constructions

a. Q: Who did John introduce Bill to?
   A: John introduced Bill to [SUE]$_F$

b. Q: Who did John introduce to Sue?
   A: John introduced [BILL]$_F$ to Sue

The truth conditions of the answers in (110a) and (110b) are presumably the same, however, the difference in the positioning of focus in the answers has the effect of making salient different sets of alternatives (of the form 'John introduced Bill to x' in (110a) and 'John introduce y to Sue' in (110b)). The pragmatic function of focus in answers could be viewed as introducing the set of potential answers for the question or more specifically the set of potential answers that contrasts with the asserted answer (Rooth 1992).

As evident from (106-110) the same prosodic feature of focal accent can be used to construct the content of an utterance by inducing truth-conditional differences in some cases, and to affect information structure and implications in other cases. The following section addresses the possibility of utilizing the duality of focus in semantic and pragmatic interpretations in order to explore the nature of the AS participants' difficulty.

10.2.3. *Pragmatic*s or *Focus*?

As emerges from the findings of the present study, the AS test-group demonstrate significant differences in the tasks in which focus induces a pragmatic change of information structure, i.e. the *Association with focus – Negation task* and the two *Suitable answer tasks*. In these tasks, *focus* does not alter the formal semantic meaning of any of the stimuli and does not induce a change of grammatical relations or truth conditions. Appropriate response to the stimuli in these tasks depends on the ability to draw the proper implications based on the location of the focused constituent. Although the experimental layout of the present study does not include an assignment in which focal accent induces a semantic change of truth conditions, a few recent studies of various methodologies might provide further evidence for a possible selective difficulty in the autistics' ability to perceive and use *focus*.

Nieuwland et al. (2010) found that neurotypical participants which achieved high scores in the *Autistic Spectrum quotient* (Baron-Cohen et al. 2001) and in the *communicative subscale* in particular (i.e. displayed autistic-like characteristics) are distinguished from their non-autistic-like peers in accepting pragmatic violations of informativeness in cases in which the violation stems from a focus-dependent interpretation. In this ERP study participants were asked to read sentences that were either informative (e.g. *'Some people have <u>pets</u>, which require good care'*) or underinformative (e.g. *'Some people have <u>lungs</u>, which require good care'*). The sentences were presented in two versions as *absolute underinformative statements* in the form of a non-restrictive relative clause (e.g. *'Some people have lungs, which require good care*', experiment I) and as *locally underinformative statements* in the form of a restrictive relative clause (e.g. *'Some people have lungs that are diseased by viruses'*, experiment II). [21] The sentences were presented word by word on a computer

[21] The underinformative condition in experiment I was simply termed *underinformative* in Nieuwland et al. (2010). The addition of *absolute* to the condition's name is mine, in order to clarify the distinction

monitor, while brain response for the extent of semantic-fit between incoming target-word and information stored in memory was measured by N400 amplitude. The authors hypothesized that following a sentence fragment with a scalar item such as *'Some people have…'* the recipient should expect the upcoming word to denote something that is not possessed by all people (e.g. *pets* and not *lungs*). N400 activation, indicating semantic processing cost, was therefore predicted in cases of underinformative statements, in which the target-word was trivially true and therefore less expected in terms of semantic fit. However, this response was expected to emerge only for the *absolute underinformative statements*. According to the authors, the *comma* after the target-words in the *absolute underinformative statements* puts the target-word into focus and signals the end of the quantification domain of the scalar item *some*. The authors presumed that while unfocused material receives a low-level "shallow" lexical-semantic interpretation, it is the focused position of the target-words in the *absolute underinformative statements* that triggers the multilayered processing that is required for a complete semantic and pragmatic interpretation. Interestingly, the expected N400 activation following target-words in the *absolute underinformative statements* was found only for the non-autistic-like group (i.e. the group with normal communication skills), while the autistic-like group's brain response was not altered between the *absolute underinformative statements* and the *locally underinformative statements*. This response pattern apparently indicates that the target-word in the *absolute underinformative statements* did not evoke the relevant scalar implicatures for the autistic-like participants, which did not perceive the statement as violating pragmatic conventions of informativeness.

A large body of language-acquisition studies indicates that typically developed children at young age, may reject logical violations while tolerating pragmatic ones. It has been documented that unlike adults, children demonstrate difficulty to comprehend some of the pragmatic aspects of meaning and often fail to generate some of the conversational implicatures arising out of utterances. The *pragmatic tolerance* hypothesis (Davies and Katsos 2010), suggests that young children fail to reject under- and over-informative utterances due to a limited inference ability that enables them to access and interpret only the semantic meaning of the utterances while the metalinguistic awareness to pragmatic infelicities emerges in a later stage of

---

between this condition and the *temporary* or *locally underinformative* condition that was presented in experiment II.

linguistic and cognitive development. These theoretical accounts for pragmatic irregularities resemble some of the suggestions regarding the autistic pragmatic deficit. However, the predictions arising from a theory of *pragmatic tolerance* are not entirely consistent with the behavior and performance of the autistic participants. With regard to the pragmatic notion in question, at least some of the findings regarding scalar inferences in autism confirm that autistic individuals are just as likely as controls to derive scalar implicatures for scalar items in underinformative statements (Pijnacker et al. 2009).

Nieuwland et al. (2010) suggest that the derived pragmatic violations in their stimuli are dependent on the target-word being interpreted as focused and that differences in pragmatic tolerance, between the autistic-like and the non-autistic-like participants in their study, could be interpreted as stemming from disparities in the participants' sensitivity to focus.

With regard to focus related phenomena, additional differences between individuals with and without autistic traits could be found in Xiang et al.'s (2012) study of Negative Polarity Items (NPI) licensing. Xiang et al. reported that participants who achieved high scores in the *Autistic Spectrum quotient* demonstrated a significantly smaller positivity effect in ERP recordings for sentences with the focus sensitive operator *'only'*, but showed no irregular effects for sentences with other NPI licensors. Based on these results, Xiang et al. postulate a qualitatively different mechanism for NPI licensing through *only* (inference based rather than grammar based licensing). Xiang et al.'s study did not directly concern focus related phenomena, nonetheless, it might provide some preliminary evidence indicating that autistic-like individuals interpret focus dependent operators differently than they interpret other operators, this in comparison with individuals with no autistic traits, which demonstrate the same ERP positivity effect for both types of operators. These results were echoed in Xiang et al. (2013).

A more direct evidence for different use of focus by autistic-like individuals arises from Bishop's cross-modal association priming study (Bishop 2012b). In this study it was found that participants with high autistic traits perform differently than those with low autistic traits in response to prosodic manipulation of focal accent position, in a priming task in which the prime words were embedded in an answer to a Wh-question. The priming effect of the autistic-like participants in Bishop's study showed relative stability and was not influenced by prosodic factors. It seems that

Bishop' autistic-like participants did not rely on focal accent in constructing effective context and the priming effect of these less communicative participants was suggested to reflect the processing of simple semantic meanings, which presumably feature in interpretation processes of unfocused information (Sanford and Garrod 1998, Sanford and Sturt 2002).

Bishop's suggestion is particularly interesting in that it is not specific to pragmatic uses of focus and therefore predicts similar priming patterns in response to focused prime words in other contexts. In terms of *Alternative semantics,* it seems that the autistic participants' responses to focused primes in Bishop's study reflect interpretation that is restricted to *basic semantic meaning*. These findings might indicate a limited access to the set of alternatives that are induced by the *focus semantic value* of an utterance (this notion will be further discussed in §10.3.3.1).

To the best of my knowledge no study comprehensively assessed the ability of autistic individuals to perceive and comprehend different types of focus and no study systematically compared truth-conditional effects vs. non-truth conditional effects of focus in perception tasks. However, a substantial volume of works, including the present study, reveals numerous difficulties in different aspects of focus interpretation and focus production amongst the autistic population (Baltaxe and Simmons 1985, Baltaxe and Guthrie 1987, Shriberg et al. 2001, Paul et al. 2005 among others). Based on these various findings and given the fact that some of the autistic participants in the present study, as well as in other studies, did not demonstrate extensive pragmatic deficits, it seems that viewing the autistic prosodic difficulties as resulting exclusively from a pragmatic deficit, or from some sort of tolerance to pragmatic infelicity, might be inadequate and that there are good reasons to hypothesize a distinct deficit in *focus* usage.

In order to clarify the picture and determine the range and the origin of the prosodic impairment reflected in the *focus* tasks, it is essential that future versions of the PROSA battery will incorporate additional tasks that are designated to assess comprehension of utterances in which *focus* creates semantic contrast and has a truth-conditional effect. Verification of the preliminary assumptions regarding a deficit in *focus* usage amongst the autistic population will call for an explanation of the difficulty within a focus theory and with reference to focus related operations. The following §10.3 and §10.4 will elaborate and extend this view.

10.3. Focus and alternatives – interpreting focus

Most *focus* theories that aim to explain the systematic relationship between prosodic emphasis and semantic meaning rely on the intuition that the presence of *focus* introduces a set of alternatives for the focused constituent (Jackendoff 1972, Rooth 1985, 1992, among others). According to the theory of *Alternative Semantics* (Rooth 1992), in addition to the basic meaning of the utterance, *f*-marked constituent introduces a *focus semantic value* in the form of a set of alternative meanings for that constituent.

(111) Focus and alternatives

a. $[\text{RUTH}]_F$ loves Greg

b. Ruth loves $[\text{GREG}]_F$

Therefore, the basic meaning of the sentence in (111), that is informally the proposition that *'Ruth loves Greg*', is similar for (111a) and (111b). However, the different prosodic patterns yield different focus values for the two sentences and trigger the generation of different sets of alternative propositions:

(112) Focus semantic values for the sentences in (111)

a. $[\text{RUTH}]_F$ loves Greg

{x loves Greg | x is an individual} =

{*Linda loves Greg, Paul loves Greg, Aubrey loves Greg, Fay loves Greg…*}

b. Ruth loves $[\text{GREG}]_F$

{Ruth loves y | y is an individual} =

{*Ruth loves Linda, Ruth loves Paul, Ruth loves Aubrey, Ruth loves Fay…*}

A focus on the subject *'Ruth*' (112a) requires substitution of this component with a variable and introduces a set of alternative propositional meanings of the form *{x loves Greg},* while a focus on the object *'Greg'* (112b) results in alternative propositions of the form *{Ruth loves y},* in which the object is replaced. It is argued that alternative constituents share syntactic class with the focused constituent (an NP in this example) and belong to the same semantic class (someone that can love (112a) or something that can be loved (112b)).

> *"At an intuitive level, we think of the focus semantic value of a sentence as a set of alternatives from which the ordinary semantic value is drawn, or a set of propositions which potentially contrast with the ordinary semantic value"* (Rooth 1992 p.76)

Several recent studies empirically strengthen these theoretical views regarding focus processing, by the use of cognitive experimental tools, and shed light on the psychological realization of alternatives prompted by focus (Weber et al. 2006, Norris et al. 2006, Ito and Speer, 2008, Braun and Tagliapietra 2010, Bishop 2012a, 2012b, Gotzner et al. 2013). In a cross-modal associative priming paradigm, Braun and Tagliapietra (2010) presented neurotypical Dutch-speaking participants with an auditory prime word (e.g., *'flamingo'*), embedded as an object in a sentence (e.g., *'In Florida he photographed a flamingo'*). These sentences were presented to listeners with either neutral (non-contrastive) intonation or with contrastive intonation (where the object *flamingo* was focused). The results of this study specify that for contrastive associated targets (such as '*pelican*') which are contrasting alternatives to the prime, priming effects occurred only when the prime word was accented. However, for non-contrastive generic associated target words, that are not contextual alternatives to the prime (e.g., *'pink'*), weaker priming was detected and it occurred regardless of intonation pattern. A recent study by Gotzner et al. (2013) reinforces these findings, not only by highlighting the role of focus in inducing the retrieval of alternatives, but also by revealing the direct effect of focus sensitive particles (*only, also*) on processing cost.

These findings support the above alternative sets' based formalizations of focus. It offers cognitive evidence for the assumption by which focus facilitates the generation of relevant alternatives and that these alternatives, which are not explicit in any way, form a part of the utterance meaning and affect its interpretation. In addition, the facilitation of alternatives upon hearing sentences in isolation that was observed in these studies signify that prosodic cues can serve as an ‘effective context’ for the activation of alternatives, even in the absence of explicit semantic or pragmatic context (see also Norris et al. 2006).

An important step in the investigation of the AS difficulty should include, therefore, an evaluation of the AS participants' ability to perform the operation of alternative computation that underlie focus interpretation. It is important to note,

however, that this operation is not limited to the interpretation of focus, and characterize other semantic and pragmatic processes such as the interpretation of *Wh-questions* (Hamblin 1973, Karttunen 1977, Rooth 1992, Beck 2006 among others) and of *Scalar Implicatures* (Horn 1972, Gazdar 1979, Rooth 1992, Katzir 2007, Fox and Katzir 2011).[22] Since the AS participants' were no different than control in their ability to comprehend *Wh-questions* (§10.3.1) and *Scalar Implicatures* (§10.3.2), their difficulty in the *focus* tasks could not be explained as stemming from a general deficit in alternative computation.

10.3.1. Generating alternatives in Wh-Questions

Following Hamblin (1973) and Karttunen (1977) proposals, the denotation of a Wh-question is assumed to be the set of potential answers to the question:

> *"A question sets up a choice-situation between a set of propositions, namely, those propositions that count as answers to it"* (Hamblin 1973, p.48)

This is achieved by substituting the Wh-element with alternative constituents of the same semantic type:

(113) Who loves Greg?

Questions' denotation: {x loves Greg | x is a person} =

{*Ruth loves Greg, Linda loves Greg, Paul loves Greg, Aubrey loves Greg…*}

The denotation of the question in (113) forms a subset of the alternative set that is induces by the *focus semantic value* of the corresponding answer ((112a), repeated below as (114)) since the variable in the focus value of (109a) is not limited to *person*. The requirement for the variable in the question's denotation to be a person stems from the semantic features of the interrogative 'who' (Rooth 1992). The meaning of both question (113) and answer (114) involves generating a set of alternative propositions of the form: *'x loves Greg'*:

[22] It should be emphasized that most theories that account for the interpretation of *focus, Wh-questions* and *Scalar Implicatures* involve some notion of alternative sets as a part of the semantics of these structures. However, similarities between these structures are also evident in other frameworks, which does not necessarily postulate alternatives (e.g. movement theories, Chomsky 1976).

(114) [RUTH]$_F$ loves Greg

Basic semantic value: {*Ruth loves Greg}*

Focus semantic value: {x loves Greg | x is an individual} =

{*Linda loves Greg, Paul loves Greg, Aubrey loves Greg, Fay loves Greg…*}

It is widely accepted that to a great extent the interpretation of Wh-questions and that of focused constituents make use of the same interpretational mechanisms; like focus, Wh-elements introduce alternatives (Hamblin 1973, Rooth 1992, Beck 2006). This assumption, regarding analogous operations that are employed in the semantic processing of both interrogatives and focused constituents can account for the apparent correlation between a Wh-element in a question and the focus position in a corresponding answer.

The results of the present study indicate that while the AS participants demonstrate significant difficulty in comprehending focus constructions, their ability to interpret Wh-questions is apparently intact. The results of the *Comprehension of relative clauses and Wh-questions task (ZST-TLAT)*, which was included in the *General linguistic skills* section of this study (a short version of table (21) is presented below as (115)), reveal that none of the participants showed significant difficulty in comprehending Wh-questions. In the vast majority of cases the AS participants were able to choose the correct character in a picture, to which the question stimulus was referring, and their success rates in this task were as high as those of the control group.

(115) Comprehension of relative clauses and Wh-questions task (ZST-TLAT)

Sentence type / Participant	**Subject Wh-question** Correct response out of 20 items	**Object Wh-question** Correct response out of 20 items
1	20	20
2	20	20
3	20	20
4	20	20
5	20	19
6	20	19
7	20	20
8	20	20
9	20	20
10	20	20
Average score of AS group (SD)	**20.0** (0.0)	**19.8** (0.4)
Average score of control (SD)	**20.0** (0.0)	**19.8** (0.4)

These results imply that the AS participants were able to perform the mere operation of generation alternatives, as they showed no difficulty in reaching the proper semantic meaning of Wh-questions.

10.3.2. Generating alternatives in Scalar Implicatures

The standard account of scalar implicatures' computation relies on a process of generating a set of alternative candidates for linguistic elements that are ranked on a common scale of informativeness, (e.g. *numerals, <or, and>, <some, many, most, all>, <sometimes, often, always>*), namely Horn scales (Horn 1972, Gazdar 1979). *Scalar Implicatures* arise when the speaker's use of a lower-ranked expression is taken to imply that the usage of a stronger, more informative, expression would be inappropriate.

The set of relevant alternatives for the scalar item *some* in (116a) include more informative items such as *most* and *all.* The *Scalar Implicatures* generated for this

sentence include the negation of stronger alternative statements such as (116b) and (116c):

(116) Scalar Implicatures

a. The grandmother ate *some* of the Popsicle

b. ¬ The grandmother ate *most* of the Popsicle

c. ¬ The grandmother ate *all* of the Popsicle

As indicated by Fox and Katzir (2011), similar process features in the interpretation of sentences with the focus sensitive operator *only*. The semantics of only requires the proposition in its domain to be true and entails the negation of every alternative proposition:

(117) Association with focus: *only*

a. John only introduced Bill to $[\text{SUE}]_F$

b. ¬ John introduced Bill to Ruth

c. ¬ John introduced Bill to Greg

While both interpretation processes are assumed to involve alternative computation, standard approaches consider the formation of formal alternative sets for focused expressions to be determined by the syntactic class and semantic type of the focused expression and restricted by context whereas the formation of alternative sets for Scalar Implicatures are assumed to be determined by Horn-scales (i.e limited to the substitution of a scalar item with a scale mate). However, recent studies suggest that the same underlying mechanism of alternative computation is shared by *Scalar Implicatures* and *focus* interpretation (Katzir 2007, Fox and Katzir 2011). Based on these suggestions alternative sets in both operations are structurally restricted in grammar by complexity and not by context.

The results of the *Scalar Implicature* task in the present study (repeated in 118) as well as the results of other studies that examined the formation of scalar inferences (such as Pijnacker et al. 2009, Chevallier et al. 2010), confirm that the autistic participants were able to compute the relevant implicatures in the context of scalar items.

(118) Computing alternatives: Scalar implicatures – group results

Scalar implicatures	***AS test-group (n=10)*** *% correct response*	***Control group (n=25)*** *% correct response*
'The girl ate some of the cake'	**100** (70/70)	**100** (175/175)

It could be deduced therefore that the participants in the current study were able to generate the relevant set of alternatives triggered by scalar items.

As noted by Rooth (1992) and further elaborated in Fox and Katzir (2011), there is a clear linkage between *focus* and *Scalar Implicatures*. The observation that *focus* can evoke the formation of *Scalar Implicatures* in certain contexts, as in (119) below, could be used in future studies for evaluating the participants' ability to generate scalar alternatives that are triggered by focus, as in the following case:

(119) How did the exam go?

a. Well, I [passed]$_F$

b. Well [I]$_F$ passed

The two answers in (119) make salient different alternative sets and therefore give rise to different inferences. The focused predicate in (119a) evokes a common scale of alternatives of the form <failed, passed, aced>. The assertion of the element *pass* in (119a) implies the negation of any higher element of the same scale, hence, (119a) asserts that the speaker only *passed* the exam and implies that he did not *ace* it. Crucially, the answer in (119a) does not imply anything about other people's performance in the exam. In contrast, the answer in (119b), in which the subject is focused, suggests that while *I* passed the exam, other people did not. This sentence, however, seems to imply nothing about whether or not the speaker did better than merely *passing*.

It would be beneficial in future studies to compare the AS participants' performance in interpreting this type of sentences, which require the formation of focus-triggered scalar alternatives, with their performance in two other types of tasks: (a) tasks that require the formation of scalar alternatives that are triggered by non-

prosodic contexts (i.e. by overt scalar items), and (b) tasks that require the computation of non-scalar alternatives that are triggered by focus. [23]

10.3.3. Interpreting *focus*

The above observations lead to the conclusion that the AS difficulty could not reflect a general deficit in the full range of semantic operations that involve the generation of alternative sets. Therefore, it seems that the AS group's deficit is specific to focus comprehension.

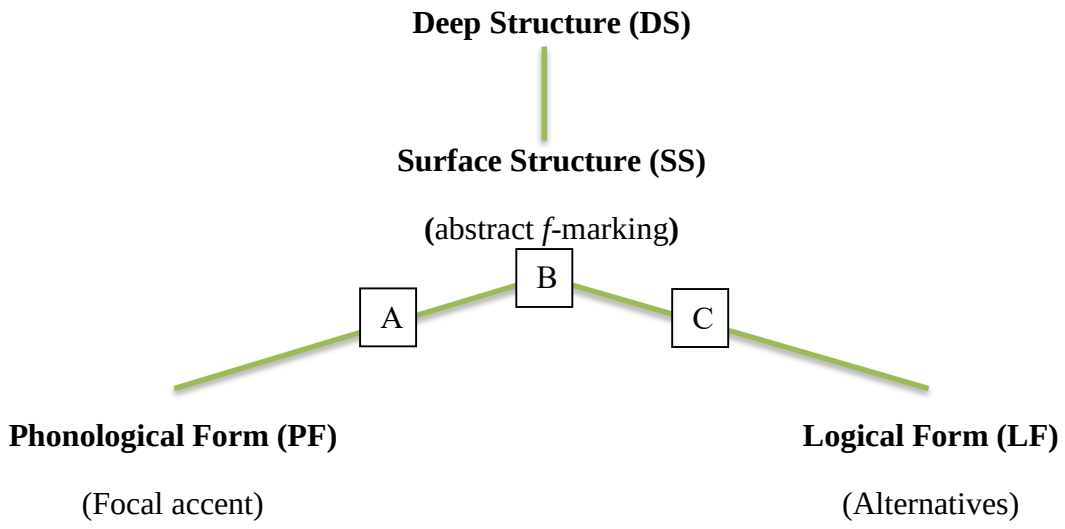
Since focus has both phonological and semantic correlates, standard theories of focus representation assume an abstract focus feature to be syntactically marked in the Surface Structure of an utterance (Jackendoff 1972, Selkirk 1984, Rooth 1985). Based on the above observations regarding the AS participants' difficulty, and after eliminating some of the possible sources for this difficulty, three potential sites in the modal of grammar, as reflected by the *Extended Standard Theory* (Chomsky 1972,

---

[23] Chevallier et al.s' study (2010) intended to explore the interaction of focus and scalar implicatures amongst autistic individuals. The authors aimed to evaluate whether children with ASD are less prone than typically developed individuals to compute scalar inference in response to a focused connective *or* in a disjunctive utterance. Based on Chevallier et al.s' (2008) findings the authors assumed that focusing the connective *or* will enhance the *exclusive* reading of *or* and encourage participants to produce pragmatic inference. The participants were presented with a picture of two objects and were asked to determine whether a statement (a conjunction or a disjunction) was *true* or *false* in the context of the picture. The relevant condition for our discussion is that in which a statement such as: *'there is a sun OR a train'* was presented in the context of a picture of a *sun* and a *train*. In this condition either a *true* or a *false* answer is acceptable. A *true* response indicates that the participant gave logical interpretation (*sun* or *train* <u>or both</u> (inclusive *or*)) whereas a *false* response indicated pragmatic scalar inference (e.g. *sun* or *train* <u>but not both</u> (exclusive *or*)). The results did not indicate any significant differences between the ASD group and the control group in rates of pragmatic inferences. The ASD group's responses reflected an *exclusive* interpretation of *or* in 52% of sentences and the control group reflected the same pattern of interpretation in 57% of sentences. According to the authors, these findings suggest that the ASD participants do not differ from control in their ability to use focus as a trigger for scalar inference. However, since Chevallier et al.'s experiment did not evaluate the participants' performance in the same type of sentences **without** *focus*. I tend to believe that no concrete conclusions regarding the influence of focus on the formation of scalar alternatives could be drawn in this case. Firstly, in contrary to the effect of focus as a sole trigger for scalar inferences in (120), the connective *or* is a *scalar item* in nature and therefore, according to the standard theory (Horn 1972), associates with scalar alternative, at some level, regardless of being focused or not. Therefore, it should be considered whether the effect of a focused scalar item on scalar implicatures could unambiguously and straightforwardly reflect the influence of focus on scalar inference. Secondly, and more importantly, I believe that in order to assess the possible influence of focus on interpretation within the experimental model suggested by Chevallier et al. (2010) it is essential to test the rate of *inclusive* and *exclusive* interpretations disjunctions with **unfocused** *or* amongst the two groups of participants. To the best of my understanding, only if it would be found that there is in fact an overt change in rates of *exclusive* and *inclusive* inferences in response to disjunctions **with** and **without focused *or*** amongst **both research groups** (ASD and control) the validity of Chevallier et al.s' conclusions will be reaffirmed.

Chomsky and Lasnik 1977), could be hypothesized as possible sources for the AS deficit in focus perception (see A-C in (120)).

(120) The organization of grammar



In the case of the present study (and, to the best of my knowledge, in all other studies concerned *focus* perception), alternatives that are induced by focus are unique in that they are triggered by and exclusively dependent on prosodic cues whereas other alternative sets are generally lexically-triggered (e.g. by Wh-elements and scalar items). This uniqueness of focus motivates the interface of PF and SS to be a possible source for the AS participants' deficit, *A* in (120). A flaw in the association between focal accent, the prosodic manifestation of focus, and focus marking in syntax could lead to inappropriate interpretations of focused expressions. This schematic hypothesis has, in fact, some very concrete predictions:

(121) *If the AS difficulty is limited to the interpretation of <u>prosodic focus</u>, we should expect that the AS participants will be able to perceive and comprehend non-prosodic manifestations of focus as in written language or in cases of unaccented foci in Second Occurrence Focus.*

If, however, it will be found that the AS participants lack the ability to interpret other *f*-markings, it would be less likely to assume that the source of difficulty is in the interface of prosody and syntax (*A* in (120)). A more reasonable hypothesis, under these circumstances, would locate the deficit in syntax (*f*-marking in SS) or in the association between syntax and semantic interpretation in LF, *B* and *C* in (120).

A hypothesis' regarding a syntactic deficit of *f*-marking (*B* in (120)) is expected to yield the following:

(122) *If focus has no syntactic realization (e.g. no f-marking in SS), the AS participants are expected to have no access to focus semantic value of utterances. Hence, no alternative sets are expected to be formed.*

A hypothesis' regarding deficiency of the interface of syntax and semantics (*C* in (120)) might be perceived as a total absence of focus semantic value (as in (122)) or it might yield the following:

(123) *A deficit in the semantic interpretation of f-marked constituent might lead to the formation of inappropriate alternative sets.*

These various hypotheses give rise to some key questions regarding the AS ability to interpret focus constructions that are not explicitly emphasized by prosody, and regarding the AS ability to generate (the proper set of) alternatives for focused expressions. Further research is required in order to thoroughly examine these various hypotheses, however, preliminary and partial answers might be drawn from recent work by Nieuwland et al. (2010) and Bishop (2012b), indicating that autistic-like individuals show altered priming effects for alternative sets of focused elements and different patterns of brain activity when interpreting focus, this in comparison with individuals that show no autistic traits.

10.3.3.1. *Is the AS difficulty in focus interpretation limited to explicit prosodic emphasis?*

The findings of the present study lead to the understanding that autistic individuals demonstrate difficulties in inferring and interpreting *focus* when it is indicated by explicit prosodic prominence. Generally, all foci are pitch accented and pitch accent is by far the most reliable trigger for *focus*. However, *focus* is not an exclusive auditory phenomenon.

It was suggested that foci in Second Occurrence Focus (SOF), though prosodically prominent in terms of duration, are not marked with pitch accent and differ from ordinary focus (Rooth 1996, Beaver and Clark 2003, Büring 2015). Focus could also be syntactically marked via word order as in Cleft constructions (with the addition of obligatory intonation break and pitch accent) and it could be expressed in

various ways in written language. Structural properties of a written utterance can be manipulated in various ways. It has been established that focus, as well as other prosodic cues, are inferred in reading tasks based on syntactic structure indicated by punctuation, focus-sensitive particles or canonical syntactic constructions (such as cleft constructions). Focus could also be indicated in written language by using meta-lingual markers, e.g. underlines or bold, capital or italic letters that visually emphasize specific words in an utterance (McAteer 1992, Birch and Rayner 1997, Hirotani et al., 2006, Stolterfoht et al. 2007). These studies provide evidence for the influence of focus on syntactic and semantic processing in various reading tasks.

The findings in Nieuwland et al. (2010), discussed in §10.2.3, suggest that brain activity during semantic processing of pragmatic underinformativness in written utterances, distinguishes autistic-like individuals from their peers only in cases in which the pragmatic violation arises from a focus-dependent interpretation of the utterance. In two ERP experiments, Nieuwland et al. (2010) used reading task in order to measure brain activity in response to a target word (e.g. *lungs*) in underinformative utterances such as *'Some people have lungs'*. These sentences were presented word by word in two contexts – an *absolute underinformative* context, such as *'Some people have lungs, which require good care*' and a *locally underinformative* context, such as *'Some people have lungs that are diseased by viruses*'.

N400 ERP component, an electrophysiological index of semantic processing and 'semantic fit', is expected to be evoked in response to underinformativeness. This potential was measured for target words in each sentence. The findings of this study indicate that *locally underinformative* utterances failed to evoke N400 effect overall, however, in underinformative utterances, in which the target word (e.g. *lungs*) was followed by a comma, autistic-like individuals, differs from their peers in N400 pattern. While individuals with low autistic traits showed relative larger N400 amplitude, indicating high semantic processing cost that is expected to feature in the processing of underinformative utterances, autistic-like individuals showed relative low N400 amplitude for these pragmatically underinformative utterances, indicating processing of "shallow" lexical-semantic relations. Nieuwland et al., assume that the comma in the underinformative utterances locate the clausal-final word *'lungs'* in focus position**.** These apparent differences between the two groups disappeared,

however, in utterances with *locally underinformativeness*, in which target words were unfocused.

The findings of Nieuwland et al. (2010) might provide some preliminary evidence for a possible inability of autistic-like individuals to interpret focus constituents that are not auditorily emphasized. However, further study is required in order to clarify the picture regarding the AS-test group's observed deficit and in order to determine whether this deficit is limited to focus constituents that are marked auditorily or does it characterize all syntactically *f*-marked constituents, regardless of explicit prosodic prominence.

10.3.3.2. *Can the AS participants form alternatives for focused elements?*

Bishop (2012b) use a cross-modal associative priming task to test whether prenuclear accent on the verb, in addition to a nuclear accent on the object, is optional in the expression of narrow object focus in an SVO structure. The study aimed to examine predictions based on production studies as well as on theoretical accounts such as Selkirk's projection theory (1995), by which prenuclear accent is expected to be infelicitous in expressing narrow focus. The participants listened to two types of sentences containing a focused object; one including a prenuclear accent on the verb and the other did not. A target word was presented visually after each prime and the participants were asked to make lexical decision in response to these targets. Positive priming effects were defined as mean reaction time differences in response to visual targets (e.g. the word *leg*) after control primes (prime words that were not related to the target word, e.g. the word *horse* in the sentence *'I hurt my horse'*) versus after related-contrastive primes (e.g. the word *hand* in *'I hurt my hand'*). The results of this study indicate that individual differences in autistic traits (as measured by the *Autism Spectrum Quotient - Communication subscale*) interact crucially with the prosodic manipulation. For individuals that scored low on the *Autism Spectrum Quotient* scale (i.e. showed typical communicative behavior) facilitation of priming for narrow focus was evident only in the absence of a prenuclear accent on the verb. These participants reacted faster to targets after primes that were contrastively related to the target than to targets after unrelated control primes only in sentences that lacked prenuclear accent and matched the expected felicitous pattern for narrow object focus. In sentences with prenuclear accent on the verb, these participant showed inhibition of priming effects and reacted slower to targets after related-contrastive primes than after

unrelated control primes. Conversely, individuals that were characterized with autistic traits were less sensitive to prosody and showed facilitation of priming, to some extent, regardless of prosodic pattern. These participants reacted faster to targets after related primes than to targets after unrelated primes in sentence **with and without** prenuclear accent on the verb. Moreover, individuals at the very top end of the *Autism Spectrum Quotient* (the most autistic-like individuals) demonstrated an opposite trend of facilitation and inhibition of priming in comparison with non-autistic-like participants. These autistic-like participants reacted faster to targets after related primes than to targets after unrelated primes only in sentences **with** prenuclear accent on the verb.

These differences in prime effects for alternatives, together with the evidence for a selective deficit in focus interpretation that was detected in the present study, could provide initial indication that the autistic-like participants are not simply less sensitive to prosody but that they might actually process prosodic cues that associate with focus in a different manner than their peers. Previous studies have established the psychological realization of alternatives by indicating that listeners infer alternatives triggered by focal accent (Weber et al. 2006; Ito and Speer, 2008, Braun and Tagliapietra 2010, Gotzner et al. 2013). However, the underlying mechanisms that are used to achieve the proper set of alternatives are yet to be studied.

Bishop (2012b) refers to two possible explanations for the different use of prosody by autistic-like individuals in his study. He first assumes that individuals with autistic features generate "incorrect" set of alternatives, an operation that leads to the suppression of the correct alternative set. This possibility could be in line with Husband and Ferreira's (2012) proposal, according to which the generation of alternative sets in neurotypical individuals is the result of a two-stage operation: (a) activation of semantic related associates, both contrastive and non-contrastive, for a focused element, and (b) suppression of non-contrastive associates. This proposal is also in line with the results of Gotzner et al. (2013), indicating that contrastive alternatives maintains facilitation over time only in a context of contrastive focus, whereas in unfocused contexts it decays.

Based on such an account, autistic-like individuals are not expected to differ from their peers in the fundamental use of prosody as a trigger for alternative computation. This route of analysis opens the possibility that individuals with high autistic traits do in fact generate alternatives for focused element but suppress the

wrong set of contrastive alternatives. A deficit of this sort might lead to the activation of improper alternative set and inappropriate semantic representation and could possibly account for the incorrect response pattern found in the present study and for the atypical inhibition pattern found in Bishop's study (2012b). In addition, this line of analysis predicts that for individuals with high autistic traits, focused elements might facilitate non-contrastive alternatives. These concrete predictions can be examined using priming tasks and other measures (appropriateness judgments for instance), in future studies.

Another mechanism, suggested by Bishop as a possible explanation for the autistic-like participants' reaction pattern in his study, is based on the assumption that inhibition in associative priming could result, in some cases, from attentional suppression and therefore might stem from limitations of processing resources. Several studies, such as Neill (1977) and Tipper (1985), suggest that inhibition of priming effects may occur when participants are asked to actively ignore related primes. Assuming this view, Bishop addresses the possibility that autistic-like individuals actively shift attention away from prosodic prominence due to extreme burden on their limited attentional resources. This suggestion is in line with views that refer to the autistic difficulty as stemming from a general deficit in executive functions. However, this hypothesis is not specific enough to account for the participants' selective difficulty in the use of only some of the various prosodic cues. If the integration of prosodic information constitutes great burden on attention resources, why is it only prosodic focus that is "ignored" while other aspects of prosody are felicitously integrated and interpreted in the process of language comprehension? The validity of this hypothesis, therefore, is questionable and should be further examined.

The results of the above studies give preliminary support to the assumption that individuals with autistic features might perform the operation of alternative computation induced by *focus* differently than typical population. In order to evaluate assumptions regarding the actual defected mechanisms that create these differences further study is required.

10.4. Constraints on focus assignment

Another route that should be considered in the process of defining the AS-participants' difficulty arises from Schwarzschild's constraint-based theory of focus assignment (1999). Schwarzschild's theory aims to explain focus position within utterances by suggesting that focus assignment is limited and determined by a set of competing, hierarchically ranked constraints (Prince and Smolensky 1993).

Since the basic generalization regarding accent placement and discourse status requires *Non-f-marked* constituents to be *Given*, in order to explain this correlation and predict where and when *f*-marking is required, Schwarzschild formalize the term of *Givenness* and suggest a novel definition for *Given* expressions according to which a *Given* expression must be contextually entailed by prior discourse.

(124) Definition of *GIVEN* (Schwarzschild 1999, informal version, p. 151)

An utterance *U* counts as *GIVEN* iff it has a salient antecedent *A* and:

a. if *U* is *type e*, then *A* and *U* corefer;

b. otherwise: modulo ∃-type shifting, *A* entails the existential *F*-closure of *U*

Schwarzschild suggests that any type of linguistic expression can be *Given*, even if it is entailed only by proposition fragments and not by the entire prior discourse. Hence, in order to establish entailment relations (that are generally limited to propositions), he posit a type shifting operation that existentially close unfilled constituents and raises them to *type t* (the type of propositions). This operation transforms unfilled syntactic arguments into full propositions so that it is possible to determine their discourse status and evaluate entailment relations (German et al. 2006). Schwarzschild terms this operation: *Existential type shifting (∃-type shifting)*. The *Existential f-closure* of an utterance that contains *f*-marked constituent is reached by a different existential quantification operation that binds *f*-variables. The *Existential f-closure* of an utterance is the result of replacing *f*-marked phrases with existential bound variables.

For instance, the existential *f*-closure of the sentence in (125a) is (125b).

(125) Existential *f*-closure of a proposition (∃ binding of *f*-variables)

a. $[\text{RUTH}]_F$ loves Greg

b. ∃X[X loves Greg]

In order to evaluate whether this utterance could form a felicitous answer to the question in (126), the existential closure of the interrogative should entail the existential *f*-closure of the answer. Since interrogatives are not considered propositions, they too are assumed to shift their meaning by the use of type shifting, an operation that results in a proposition in which the Wh-element is substituted for an existentially bound variable.

(126) Existential closure of an interrogative

a. Who loves Greg?

b. ∃y[y loves Greg]

The existential closure of the interrogative in (126a) is, therefore, a proposition according to which the set of propositions of the form *'y loves Greg'* is not empty.

Based on Schwarzschild formalization of *Givenness*, it is possible to determine whether the *Existential f-closure*s of the answer's various constituents are entailed by the *Existential closure* of the interrogative:

(127) Entailment relations of question (126) and answer (125):

a. The **IP** of (125): $\{[\text{RUTH}]_F$ loves Greg$\}$ is **GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (126))

Entails -

∃X[X loves Greg] (*Existential f-closure* of the IP in (125))

b. The **VP** of (125): {loves Greg} is **GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (126))

Entails -

∃y[y loves Greg] (*Existential f-closure* modulo type shifting of the VP in (125)

c. The **V** of (125): {loves} is **GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (126))

Entails -

∃x∃y[y loves x] (*Existential f-closure* modulo type shifting of the V in (125)

d. The **Object NP** of (125): {Greg} is **GIVEN** because it is a *type e* expression and has an antecedent in (126) with which it corefer (the expression is literally repreated)

e. The **Subject NP** of (125): {[RUTH]$_F$} is **not GIVEN** because it is a *type e* expression and has no antecedent in (126).

The *Existential closure* of the interrogative in (126) entails the *IP*, the *VP*, the *V* and the *Object NP* of the answer in (125), hence these expressions are *GIVEN* in the context of the questions and do not require f-marking. The *Subject NP* is not *GIVEN* in this context and therefore has to be *f*-marked in order for the answer (125) to be felicitous in the context of the question (126).

The *Existential f-closure* of the following answer in (128) is **not entailed** by the *Existential closure* of the interrogative in (126) and therefore it is infelicitous in the context of (126):

(128) Existential *f*-closure of a proposition (∃ binding of *f*-variables)

a. Ruth loves [GREG]$_F$

b. ∃X[Ruth loves X]

(129) Entailment relations of question (126) and answer (128):

a. The **IP** of (128): {Ruth loves [GREG]$_F$} is **not GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (126))

Does not entail -

∃X[Ruth loves X] (*Existential f-closure* of the IP in (128))

b. The **VP** of (128): {loves [GREG]$_F$} is **not GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (128))

Does not entail -

∃X∃y[y loves X] (*Existential f-closure* modulo type shifting of the VP in (128)

c. The **V** of (128): {loves} is **GIVEN** since:

∃y[y loves Greg] (*Existential closure* of the interrogative in (126))

Entails -

∃x∃y[y loves x] (*Existential f-closure* modulo type shifting of the V in (128)

d. The **Object NP** of (128): {[GREG]$_F$} is **GIVEN** because it is a *type e* expression and has an antecedent in (126) with which it corefer (the expression it literally repreaded)

e. The **Subject NP** of (128): {Ruth} is **not GIVEN** because it is a *type e* expression and has no antecedent in (126)

The *Existential closure* of the interrogative in (126) does not entails the *IP*, the *VP*, and *Subject NP* of the answer in (128), hence, these expressions are not *GIVEN* and the answer is not felicitous in the context of the question (126).

In order to account for the distribution of focus and its effects on discourse appropriateness, Schwarzschild suggest a constraint-based grammar and introduces several constraints, including the following:

(130) Constraints on focus assignment (Schwarzschild 1999)[24]

a. *GIVENNESS*: A constituent that is not F-marked is given

b. *AVOIDF*: Do not F-mark

Ranking: *GIVENNESS* » *AVOIDF*

GIVENNESS (130a) requires that every constituent within a sentence that is not *f*-marked will be given, that is, according to Schwarzschild; these constituents should be entailed by the context. *AVOIDF* (130b) requires not to *f*-mark. These constraints should be crucially ordered such that *GIVENNESS* outranks *AVOIDF* since the reversed ranking will prevent any *f*-marked elements from appearing in the surface representation. Based on this theory, Schwarzschild asks to explain the distribution of focal accent and to predict in which positions focus will be obligatory, in which positions it will be banned, and which positions will allow an optional focus marking.

According to the results of the focus tasks in the present study, the AS participants judge prosodically mismatched answers, which violate both *GIVENNESS*

[24] There are two other constraints suggested by Schwarzschild which will be ignored here:
FOC:A Foc-marked phrase contains an accent
HEADARG**:** A head is less prominent than its internal objects

and *AVOIDF* (131b), as suitable responses to the context question (131a). As expected according to Schwarzschild's theory of focus assignment, this type of non-optimal answers was rejected by most of the participants of the control group.

(131) Prosodic mismatch: non-optimal answer

a. Context question: ma ha-yeled axal? *'What did the boy eat?'*

b. Answer: ha-[YELED]$_F$ axal tapuax. *'The BOY ate an apple'*.

The answer in (131b) violates *GIVENNESS* since the *Existential closure* of the interrogative *∃y[the boy ate y]* does not entail the *Existential f-closure* of the answer's IP: *∃X[X ate an apple]* nor that of the answer's VP: *∃y[y ate an apple]*, therefore, according to Schwarzschild, the IP and the VP cannot be accounted as given and the focus pattern of the result should count as a violation of *GIVENNESS*. *AVOIDF* is violated in this answer since the utterance contains an *f*-marked constituent.

The fact that the AS participants accepted (131b) as a suitable answer for the context question might suggest that according to their grammar this pattern of answer is equivalent, in terms of Optimality Theory, to the expected optimal answer, (132b), that violates only *AVOIDF* and respects the constraint of *GIVENNESS* (the *Existential closure* of the interrogative in (132) *∃y[the boy ate y]* entails the *Existential f-closure*s of the answer.

(132) Prosodic match – optimal answer

a. Context question: ma ha-yeled axal? *'What did the boy eat?'*

b. Answer: ha-yeled axal [TAPUAX]$_F$. *'The boy ate an APPLE'*.

This assumed equivalence could be achieved if we surmise that the AS participants do not compute, or alternatively ignores, violations of *GIVENNESS*. With respect to *AVOIDF*, since both answers (131b) and (132b) equally violate *AVOIDF*, there is no sufficient data at this point to evaluate the AS participants' ability to appropriately compute violations of *AVOIDF*.

Since all instances of prosodic mismatches that were used in the focus tasks in the current study were in the form of (131b) and presented an inherent violation of the two constraints, it is impossible to offer, at this stage, a comprehensive explanation of the participants' pattern of response within Schwarzschild's constraint based model. Therefore, in addition to the types of stimuli that were used in the present study

(answers (131b) and (132b) repeated as candidates (133a) and (133d) in the following tableau), a prosodic mismatch condition in future experiment should include stimuli with both under-application and over-application of focus assignment (candidates (133b) and (133c) respectively).

(133) Relevant stimuli for future experiment – Constraints on focus assignment

Context question: ma ha-yeled axal? *'What did the boy eat?'*

		Utterance	***GIVENNESS***	***AVOIDF***
a.		*ha-[YELED]$_F$ axal tapuax* *'the BOY ate an apple'*	*!	*
b.		*ha-yeled axal tapuax* *'the boy ate an apple'*	*!	
c.		*ha-[YELED]$_F$ axal [TAPUAX]$_F$* *'the BOY ate an APPLE'*		**!
d.	☞	*ha-yeled axal [TAPUAX]$_F$* *'the boy ate an APPLE'*		*

The infelicitous candidate in (a) violates both constraints, and within an Optimality Theory account should be considered harmonically bound, since it is not expected to surface as the optimal output under any constraint order (Prince and Smolensky 1993). The new candidates, (b) and (c), better suit as a competition for the optimal candidate (d), and therefore should be taken under consideration in future experiments. Candidate (b) represents a case of under application of focus. This candidate violates *GIVENNESS* constraint since the IP:[*the boy ate an apple*] is not entailed by the context question. This candidate does not violate *AVOIDF* constraint since it does not contain any *f*-marked constituent. The candidate in (c) represents a case of over-application of focus assignment. This candidate respects *GIVENNESS* constraint, since the *Existential f-closure* of the utterance *∃X∃Y[X eat Y]* is in fact entailed by the context question. This candidate, however, violates *AVOIDF* twice, since it contains two *f*-marked expressions. Candidate (d) is the optimal candidate. It respects the high ranked *GIVENNESS* constraint and minimally violates the *AVOIDF* constraint.

This constraint based grammar accounts for the intuition regarding the appropriateness of the different utterances with respect to focal accent placement. It

correctly predicts that candidate (d) will sound appropriate in the discourse as an answer to the context question while candidates (a)-(c) will be rejected. Obviously, this intuition regarding utterance appropriateness is not shared by the AS test group. However, an examination of the AS participants' judgments with respect to all three infelicitous candidates might enable an inside look at their grammar and could potentially provide evidence for their ability or inability to compute violations for the relevant constraints.

Hypothetically, if the AS participants will be asked to rate the appropriateness of the different candidates in the above tableau, favoring of candidate (b) over all other candidates will support the assumption regarding their inability to refer to violations of *GIVENNESS*. Moreover, this sort of preference will indicate an ability to compute violations for *AVOIDF*. Favoring candidates (a) and (d) over candidate (c) could further reinsure these assumptions.

Obviously, this line of analysis requires further consideration in order to experimentally address these very preliminary hypotheses. However, applying this sort of systematic comparison of focus patterns in future experiment might help in reaching clearer picture of the AS participants' deficit with regard to focus distribution and to the limitations on focus assignment.

10.5. Explaining the common difficulty in *focus* perception: Summary

Supported by the findings of various other studies, the observed dissociation between the prosodic performance of the AS participants and other cognitive and linguistic abilities that were evaluated in the present study (e.g. Theory of Mind, Verbal IQ, Working Memory), promote the hypothesis that the difficulty of at least some of the AS participants might stem from inability to properly process and interpret focus.

This hypothesis was addressed from a perspective of prominent semantic models of focus interpretation (*Alternative Semantics* Rooth 1985, 1992) and focus assignment (Schwarzschild 1999). Empirical findings from recent experimental studies that investigated focus processing were presented. These findings provide both direct and indirect evidence for cognitive realization of some of the suggested theoretical mechanisms that underlie focus perception (e.g. focus induced alternatives), and reinforce assumptions regarding a possible failure in the autistic population's ability to engage these mechanisms in interpreting focus. The

examination of the participants' difficulties and strengths that was presented in this section made it possible to start defining the scope and boundaries of their incompetence. Yet, the exact nature of the AS deficit in focus perception and the specific features of their failure are still unclear and require further study.

11. Prosodic functions

Another aspect of the results that should be discussed is the common classification of prosodic patterns to distinct prosodic functions.

'Prosody' is by no means a homogeneous phenomenon. Traditional views distinguish several prosodic functions that could be roughly categorized as – grammatical, pragmatic and affective prosody (Crystal 1986, Merewether and Alpert 1990, among others). However, while the categorization of prosodic functions has clear advantages in terms of typology and is a necessary step in order to solidly describe the role of prosody in discourse, the employment of this classification within the field of prosodic deficits and especially deductions regarding deficiencies of different prosodic functions should be drawn very carefully.

The literature in the field of prosodic deficits in autism is conflicting with regard to classification of prosodic functions. This is mainly reflected in the distinction between pragmatic and emotive aspects of prosody but it is in fact a broader issue that should be discussed in relation to the general notion of defining prosodic deficits in terms of prosodic functions.

Peppé et al. (2007) reported that autistic individuals show tendency to mistakenly judge questions as statements. In their analysis, they addressed the ability to distinguish declaratives from interrogatives as the pragmatic ability to understand perceptual cues of turn-taking in conversation. Paul et al. (2005) addressed this distinction as a grammatical aspect of prosody (since questions and statements differ in their truth conditions) and found no difference between the group of autistics and the control group (as did Erwin et al. 1991, Shriberg et al. 2001 and Chevallier et al. 2009 among others). The experimental paradigm in Paul et al. (2005) comprised of three aspects of prosody (*stress, intonation* and *phrasing*) that were assessed in two functional modes – *Grammatical function* and *Pragmatic/Affective function*. Under the united title of *Pragmatic/Affective function*, Paul et al. included a task that evaluated participants' ability to perceive intonation patterns signaling register alterations (child directed vs. adult directed speech), a task that assessed the

participants' ability to detect anxiety conveyed by rate of speech and phrasing, and a task that examined focus comprehension. This merging of pragmatic and affective functions would have missed some of the distinctions that emerged in the present study. In terms of prosodic functions, the results of the present study indicate that pragmatic aspects of prosody and affective aspects of prosody can be independently affected to some extent, since at least four participants (subgroup (b)) showed a significant difficulty in the focus tasks and did not show any systematic deficiency in the affect tasks.

(134) Dissociation between pragmatic and affective aspects of prosody

Subgroup	**(a)**		**(b)**				**(c)**			
Participant / task	**1**	**3**	**2**	**6**	**7**	**9**	**10**	**4**	**5**	**8**
Contrastive focus *Discrimination task (20 items)*	0	**10.0**	**10.0**	**20.0**	**5.0**	0	**55.0**	**35.0**	0	**65.0**
Focus sensitive negation *Comprehension task (18 items)*	0	0	**55.6**	**33.3**	**38.9**	**27.8**	**22.2**	**33.3**	**44.4**	**100**
Focus - Suitable answer judg. *Comprehension task (36 items)*	0	0	**33.3**	**50.0**	**47.2**	**50.0**	**47.2**	**50.0**	**33.3**	**44.4**
Affect – word level *Discrimination task (17 items)*	0	0	0	0	0	0	**11.8**	**17.6**	**17.6**	**23.5**
Affect – word level *Comprehension task (17 items)*	0	0	0	**5.9**	0	0	**5.9**	0	**23.5**	**5.9**
Affect – sentence level *Discrimination task (22 items)*	0	0	0	0	**9.1**	0	**27.3**	**13.6**	**13.6**	**27.3**
Affect – sentence level *Comprehension task (22 items)*	0	0	0	0	0	0	**4.5**	**4.5**	0	**4.5**

In other cases it is not the grouping of prosodic functions, but in fact the division of functions that might be misleading to some extent. The performance of participant 10 (that was included in subgroup (c) due to pronounced difficulties in the affect tasks and in some of the grammatical tasks) was different than that of other members of subgroup (c) in that her difficulties with grammatical tasks were limited to question-statement tasks. If we follow Peppé et al. (2007) in referring to the differences between interrogatives and declaratives as pragmatic conversational

distinctions, we might adopt a different, more pragmatic, view of participant's 10 difficulties.

(135) Participant 10 of subgroup (c) (% of errors)

Subgroup	(c)			
Task / Participant	10	4	5	8
Lexical stress *Discrimination task (32 items)*	3.1	0	0	**28.1**
Lexical stress *Comprehension task (16 items)*	0	0	0	**12.5**
Syntactic phrasing *Discrimination task (40 items)*	5.0	5.0	**10.0**	**50.0**
Syntactic phrasing *Comprehension task (23 items)*	4.3	**13.0**	4.3	**34.8**
Q-S – word level *Discrimination task (18 items)*	**38.9**	**16.7**	**5.6**	**22.2**
Q-S – word level *Comprehension task (18 items)*	**11.1**	0	**11.1**	0
Q-S – sentence level *Discrimination task (20 items)*	**15.0**	0	5.0	**30.0**
Q-S – sentence level *Comprehension task (18 items)*	0	0	**5.6**	**11.1**
Contrastive focus *Discrimination task (20 items)*	**55.0**	**35.0**	0	**65.0**
Focus sensitive negation *Comprehension task (18 items)*	**22.2**	**33.3**	**44.4**	**100**
Focus - suitable answer judgment *Comprehension task (36 items)*	**47.2**	**50.0**	**33.3**	**44.4**
Affect – word level *Discrimination task (17 items)*	**11.8**	**17.6**	**17.6**	**23.5**
Affect – word level *Comprehension task (17 items)*	**5.9**	0	**23.5**	**5.9**
Affect – sentence level *Discrimination task (22 items)*	**27.3**	**13.6**	**13.6**	**27.3**
Affect – sentence level *Comprehension task (22 items)*	**4.5**	**4.5**	0	**4.5**

Do these findings suggest that participant 10 exhibits difficulties with grammatical prosody? And is it necessary to assume that the pragmatic prosody of subgroup (b) is defected while their affective prosody is intact? This sort of deduction could prove to be too general and might miss deeper connections between form and function. The ability to draw conclusions regarding a general function based on a difficulty manifested in a specific prosodic pattern or patterns that are related to this function is, at best, limited, and due to the complex nature of prosody, might even be misleading in some cases.

Crystal (1986) points out that when it comes to deduction regarding child prosodic abilities in language acquisition, a very careful analysis should be applied:

> *'There is no one-to-one correspondence between the above categories of prosodic form and prosodic function, nor between any of the individual features subsumed within these categories. A rising tone, for example, signals far more than questioning meaning, and a grammatical question may be uttered using other tones than rising ones. It is accordingly fallacious to assume that a child who uses rising tones is thereby 'asking a question', 'making a questioning speech act', or the like: everything depends on the careful analysis of the accompanying behavior and situation before one can be justified in ascribing such an interpretation to the utterance"*. (Crystal 1986, p.37).

The observed inconsistencies in experimental paradigms and in analysis approaches are therefore not surprising and reflect the complex and diverse role of prosody in discourse. Conventional views that assume some functional separation between grammatical and pragmatic aspects of prosody predict, in fact, that certain structures such as *interrogatives* will fall in the middle. These patterns serve several prosodic functions, sometimes simultaneously, and therefore could not be mapped to a single prosodic category. The prosody of an interrogative have a grammatical role, influencing truth condition and semantic meaning, denoting sentence type, and at the same time the prosodic contrast between questions and statements is in many ways a pragmatic tool, reflecting different speech acts and affecting discourse structure. The same goes for focal accent and for phrasing which are both prosodic cues that could affect both semantic meaning and pragmatic inferences. As noted by Ariel (2010):

> *"It seems that no one answer is appropriate for all intonation contours in all languages. Even if language-specific, not all intonation patterns necessarily encode one specific function, and inferential processes are still required. In that case, intonational interpretations result from partial codings combined with inferential processing".* (Ariel 2010, p.159)

Therefore, it seems that while the classification of prosodic functions is an important descriptive tool, within a diagnostic analysis of prosodic deficits, the merger of various prosodic patterns under the umbrella of a certain function, as well as their separation to distinct functions, could be somewhat forced. Approaching the prosodic difficulties demonstrated by the autistic population from a perspective of prosodic patterns, such as focus patterns, phrasing patterns or boundary marking patterns, might prove to be beneficial in order to provide more accurate and comprehensive description of their deficit.

12. Concluding remarks: Implications and further research

The main objective of this work was to study the range and features of the receptive prosodic impairments in Asperger syndrome. The obtained results indicate shared difficulty in all focus-related tasks. Close examination of potential accounts for this difficulty undermine assumptions regarding deficits in *Theory of Mind*, *phonological working memory*, *auditory perception*, *syntactic and lexical proficiency* or *pragmatic competence* as exclusive causes. The analysis further points out the interface of prosody, syntax and semantics, and more specifically operations that associate *prosodic accentuation* to *alternative sets*, as a potential source for the observed difficulty. However, in order to validate these assumptions and reach a more precise description of the participants' deficit, additional investigation is required.

12.1. Research implications

This study provides some directions for explaining the prosodic difficulty of the AS participants within the scope of formal linguistic theories of *focus*. The assumption that participants' deficiency might be the outcome of an impairment in their ability to associate *focus* with *sets of alternatives* is based on the observation that most AS participants (8 out of 10) experience noticeable difficulties in *focus* tasks and that at

least for some participants these difficulties seem to be independent from other linguistic and cognitive skills. In contrast, difficulties in other prosodic tasks were evident for only few participants (1 to 4 participants) and could be potentially explained on the basis of correlations with non-prosodic linguistic and cognitive characteristics, such as verbal IQ, syntactic and lexical deficiency, reduced working memory capacity and irregular pragmatic competence. Additional support to the above suggestion could be found in recent findings regarding differences in psychological realization of *alternatives* in normal and autistic-like populations. This initial proposal regarding the source of the AS group's difficulty should be further evaluated experimentally by extending the *PROSA* procedure to include additional tasks that address other uses of *focus* (e.g. semantic uses as in the case of the operator *'only'* for which focus induces a change of truth conditions), as well as additional methodologies (e.g. priming for alternatives). These additions will enable a more comprehensive view of the AS deficit and might help in achieving more adequate definition of this deficit within theoretical frameworks of *focus* interpretation. From a pure theoretical point of view, as in many other cases, language impairments constitute a fertile ground for the examination of competing theoretical models. An adequate description of the AS impairment in *focus* perception will thus enhance the ability to evaluate and compare subtle differences between theories of *focus* processing.

An additional aspect that arises from the results regards the overt diversities in participants' performance in both prosodic and non-prosodic tasks. These differences emphasize the need to apply *individual analysis*, in addition to *group analysis*, in investigations of the autistic population. Since most studies in the field of prosody in autism rely on rather small sized samples, the nonhomogeneous nature of participants' prosodic performance should be carefully considered when generalizing from small sample test-groups to larger populations (e.g. AS, HFA or ASD in general). These varieties should be also considered in the context of other cognitive abilities of the examined population, such as *Theory of Mind* skills. When investigating the extremely diverse ASD population it seems that nothing should be taken for granted. While many autistic individuals often suffer from an impaired *Theory of Mind*, this deficit does not feature in all autistic individuals. The results of the present study add to those of previous studies in undermining the hypothesis that *Theory of Mind* deficiency should be accounted as the direct cause for prosodic perception

irregularities. Moreover, the individual differences in participants' performance highlight the need to thoroughly and directly evaluate *Theory of Mind*, as well as other abilities, as a part of experimental protocols in order to provide reliable evidence for dependencies.

12.2. Clinical implications

Receptive prosodic deficits are not included in the diagnostic criteria of autistic spectrum disorders, or, to the best of my knowledge, in the description of any other neuropsychiatric syndrome. Additionally, although atypical prosody is reported to characterize the speech of many autistic individuals, and despite the fact that disrupted prosody could form major obstructions for the social integration of autistic individuals, prosody in general, and prosody perception specifically, are rarely treated by speech and language therapists. The results of the present study enable only preliminary generalizations regarding the therapeutic needs of the autistic population and yet they add to the results of various other studies of prosody in autism in highlighting the necessity and potential value of prosodic assessment and prosody oriented intervention as a part of language and communication therapy.

One interesting finding of the present study arises from the differences in prosody perception across participants within the AS test-group. While the common difficulty with focus-related stimuli features in most of the participants, difficulties with other prosodic patterns are evident for only few participants, emphasizing the diversity of symptoms among this population and stressing the need for targeted interventions and custom care. Clinicians, therefore, should be aware that much like other characteristics of the autistic population, prosodic skills vary between patients. In this respect, the employment of a wide-ranged prosodic assessment such as the *PROSA* battery that enables to identify and define specific areas of difficulty and unique limitations in individuals' performance, could contribute to clinical practice as a diagnostic device.

12.3. Future research

Several issues arise from the present study and should be addressed in future research. First, the test-group in the present study comprised of ten AS participants. Though this sample size is typical to investigations of clinical populations, applying the *PROSA* battery to larger samples of both clinical and typical populations will facilitate the

detection of small-size effects and will increase the reliability of the battery and of its attained results.

The decision to control for the verbal intelligence of the AS participants in the present study enabled the detection of independent prosodic deficits, i.e. prosodic deficits that do not necessarily correlate with other language disorders. However, due to the inclusion of only those AS participants that scored within the normal range of verbal IQ, the obtained results may not necessarily account for the broader population of autism spectrum disorders. Nevertheless, the results of the present study might be of particular interest to those who work with HFA and AS populations such as autistic children in mainstream schools[25] and autistic adults in assisted living residences, i.e. settings in which the proportion of ASD individuals with normal verbal intelligence is rather high. In order to gain broader picture of the prosodic deficit in ASD, future research should explore the differences between subgroups of the autistic spectrum and apply the *PROSA* battery to lower functioning groups.

Another aspect that should be addressed in future studies is the assessment of auditory discrimination of prosodic correlates – pitch, duration and intensity. Though unlikely to be the cause of the selective deficits that were obtained in the current study, future research should consider applying auditory assessment as integral part of the experimental protocol in order to control for possible individual differences in auditory perception that might affect prosody processing.

In terms of measures, applying reaction times analysis in addition to accuracy rates measurement provides another viewpoint of participants' performance and can potentially indicate processing differences. However, these behavioral measures might mask group differences that are the resultant of employing distinct processing strategies. Expanding assessment measures to include online indices of brain activity could be beneficial for further examination of participants' overt malperformance (e.g. in *focus* tasks). In addition, these indices could be used to reexamine the analysis of AS participants' performance in tasks in which they did not differ from control and to eliminate the possibility that control-like performance of the AS group might stem from compensatory strategies.

[25] "A mainstream School is any school that principally meets the needs of pupils who do not have special educational needs" (http://www.education-support.org.uk/parents/special-education/glossary/). In the context of the education of individuals with special needs, the term *mainstreaming* refers to the integration of pupils with special needs in regular classes.

Finally, in order to provide more comprehensive picture of the participants' deficit, the *PROSA* battery should be extended and incorporate additional *focus* tasks in order to further examine those aspects that were defined as defected (e.g. tasks which involve alternatives computation, interpretation of focus in written contexts and truth-conditional effects of focus). In order to further evaluate aspects that were found to be less vulnerable in the present study and ensure that prosodic measures of these aspects were sensitive enough to detect potential deficits, the battery should also include more complex and demanding tasks that address these aspects. Enhancement of the *PROSA* battery reliability by incorporating more fine-grained tasks, by covering additional prosodic aspects and by applying the battery to large samples of diverse populations will be an important step in devising it as both clinical and theoretical tool.

References

Abramson, Ran, (2012). *Interpreting Irony in Context among Young Adults Diagnosed with Asperger Syndrome* M.A thesis, Tel-Aviv University

Adam, Galit and Outi Bat-El. (2008). The trochaic bias is universal: Evidence from Hebrew. In *Language Acquisition and Development: Proceedings of GALA 2007*, Anna Gavarró and Maria João Freitas (Eds.), 12–24. Newcastle: Cambridge Scholars Publishing.

Adam, Galit and Outi Bat-El. (2009). When do universal preferences emerge in language development? The acquisition of Hebrew stress. *Brill's Annual of Afroasiatic Languages and Linguistics*, 1, 1–28.

Albert, A., and Zaidenberg, H. (2012). Filler Syllables in the Acquisition of Hebrew: A Prosodic Account. *BAALL* 4, pp. 162-188

American Psychiatric Association. (2000). Diagnostic criteria for 299.80 Asperger's disorder (AD). *Diagnostic and statistical manual of mental disorders* [4th, text revision (DSM-IV-TR) ed.]. Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.).* Washington, DC: Author.

Amir, N., Silber-Varod, V., and Izre'el, S. (2004). Characteristics of Intonation Unit Boundaries in Spontaneous Spoken Hebrew – Perception and Acoustic Correlates , in B. Bel and I. Marlien (Eds.), *Speech Prosody*, Nara, Japan, March 23-26: Proceedings, SProSIG (ISCA Special Interest Group on Speech Prosody), 677-680.

Ariel, M. (2008). *Pragmatics and grammar*. Cambridge: Cambridge University Press.

Ariel, M. **(2010).** *Defining Pragmatics.* Cambridge: Cambridge University Press.

Asperger, H. (1944). Die "autistischen Psychopathen" im Kindesalter. Archiv fur Psychiatrie und Nervenkrakheiten, 117, 76-136.

Astington, J. W. (1998). Theory of mind, Humpty Dumpty, and the icebox. *Human Development*, 41, 30-39.

Attwood, T. (1998). *Asperger's syndrome. A guide for parents and professionals*. London: Kingsley.

Attwood, T. (2006). *The Complete Guide to Asperger's Syndrome*. London: Kingsley.

Baddeley, A. D., and Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), The psychology of learning and motivation Vol. 8 (pp. 47–89). New York: Academic Press.

Baddeley, A. D. (1986). *Working memory*. Oxford: Clarendon Press.

Balaban, N. (2010). *The Linguistic Consequences of Acquired Damage to Theory of Mind.* Unpublished doctoral dissertation, University of Tel-Aviv, Israel.

Balaban, N., and Friedmann, N. (2010). Right Brain damage, theory of mind, and the use of reference terms. *Procedia Socialand Behavioral Sciences*, 6, 61-62.

Baltaxe, C. (1981). Acoustic characteristics of prosody in autism. In *Frontier of knowledge in mental retardation* (pp. 223–233). P. Mittler (Ed.), Baltimore: University Park Press.

Baltaxe, C. (1984). Use of contrastive stress in normal, aphasic, and autistic children. *Journal of Speech and Hearing Research*, 24, 97–105.

Baltaxe, C., and Guthrie, D. (1987). The use of primary sentence stress by normal, aphasic, and autistic children. *Journal of Autism and Developmental Disorders*, 17, 255–271.

Baltaxe, C., and Simmons, J. Q. (1985). Prosodic development in normal and autistic children. In E. Schopler and G. Mesibov (Eds.), *Issues of autism Vol. III: Communications problems in autism.* New York: Plenum Press.

Baron-Cohen, S. (1989). The autistic child's theory of mind: a case of specific developmental delay. *Journal of Child Psychology and Psychiatry*, 30(2), 285-297.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., and Robertson, M. (1997). Another advanced test of theory of mind: evidence from very high functioning adults with autism or asperger syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 38*(7), 813–822.

Baron-Cohen, S. (2000). Theory of mind and autism: A 15-year review. In S. Baron-Cohen, H. Tager-Flusberg, and D. J. Cohen (Eds.), Understanding other minds: Perspectives from developmental cognitive neuroscience (pp. 3–21). Oxford: Oxford University Press.

Baron-Cohen, S., Leslie, A. M., and Frith. U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21, 37-46.*

Baron-Cohen, S., Cox, A., Bard, G., Swettenham, J., Nightingale, N., Morgan, K.,I Drew, A., and Charman, T. (1996). Psychological markers in the detection of autism in infancy in a large population. *British Journal of Psychiatry, 168,* -158163.

Baron-Cohen, S., O'Riordan, M., Stone, V., Jones, R., and Plaisted, K. (1999). Recognition of faux pas by normally developing children and children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental disorders, 29,* 407–418.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., Clubley, E. (2001). The Autism- Spectrum Quotient (AQ): evidence from Asperger Syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders* 31, 5-17.

Bakenecker, G., Block, U., Batliner, A., Kompe, R., Noth, E., and Regel-Brietzmann, P. (1994). Improving Parsing by Incorporating 'Prosodic Clause Boundaries' into a Grammar. In Proc. *ICSLP* Vol. 3. pp. 1115-1118. Yokohama, September 1994.

Beaver, D., and Clark, B. (2003). Always and only: Why not all focus sensitive operators are alike. *Natural Language Semantics* 11, 323-362.

Beaver, D., and Clark, B. (2008). *Sense and Sensitivity: How Focus Determines Meaning*. Chichester: Wiley-Blackwell

Behrens, S.J. (1985). The perception of stress and lateralization of prosody. *Brain and Language*, 26, 332-348

Beck, S. (2006). Intervention effects follow from focus interpretation. *Natural Language Semantics*, 14(1), 1–56.

Becker, M. (2003). Hebrew stress: can't you hear those trochees? *University of Pennsylvania Working Papers in Linguistics* 9. 45–58.

Bennetto, L., Pennington, B. F., and Rogers, S. J. (1996). Intact and impaired memory functions in autism. *Child Development*, 67, 1816–1835.

Biran, M., and Friedmann, N. (2005). From phonological paraphasias to the structure of the phonological output lexicon. Language and Cognitive Processes, 20, 589-616.

Birch, S. and Clifton, C. E. (1995). Focus, accent, and argument structure: Effects on language comprehension. *Language and Speech*, 38, 365-391.

Birch, S. and Rayner, K. (1997). Linguistic focus affects eye movements during reading. *Memory and Cognition*, 28, 653–660.

Bishop, D.V.M. (1998). Development of the Children's Communication Checklist (CCC): A method for assessing qualitative aspects of communicative impairment in children. *Journal of Child Psychology and Psychiatry*, 39, 879–891.

Bishop, D.V.M. (2006) Beyond words: phonological short-term memory and syntactic impairment in specific language impairment. *Applied Psycholinguist*; 27: 569–73

Bishop, D.V.M., Bright P., James C., Bishop S.J. and van der Lely H.K.J. (2000) Grammatical SLI: a distinct subtype of developmental language impairment. *Applied Psycholinguist*, 21, 159–81.

Bishop, D.V.M., and Norbury, C. F. (2005). Executive functions in children with communication impairments, in relation to autistic symptomatology: II: Response inhibition. *Autism*, 9, 29–43.

Bishop, J. (2012a). Information structural expectations in the perception of prosodic prominence. *Prosody and meaning (interface explorations).* Berlin: Mouton de Gruyter.

Bishop, J. (2012b). Focus, prosody, and individual differences in "autistic" traits: Evidence from cross-modal semantic priming. *UCLA Working Papers in Phonetics*, 111, 1-26.

Bolinger, D. L. (1955). Intersections of stress and intonation, *Word*, 11,195–203.

Bolinger, D. L. (1958). A theory of pitch accent in English, *Word*, 14, 109–149.

Bolinger, D. L. (1989). Intonation and its Uses, Stanford University Press.

Boucher, J., Lewis, V., and Collis, G.M. (2000). Voice processing abilities in children with autism, children with specific language impairments and young typically developing children. *Journal of Child Psychology and Psychiatry*, 41, 847-857.

Bowler, D. M. (1992). Theory of Mind in Asperger's Syndrome. *Journal of Child Psychology and Psychiatry*, 33(5), 877–893.

Braun, B. and Tagliapietra, L. (2010). The role of contrastive intonation contours in the retrieval of contextual alternatives. *Language and Cognitive Processes* 25, 1024-1043.

Braverman, M., Fein, D., Lucci, D., and Waterhouse, L. (1989). Affect Comprehension in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 19, 301–316.

Büring, D. (2015). A theory of second occurrence focus, Language, Cognition and Neuroscience, 30:1-2, 73-87

Čeponiene, R., Lepisto, T., Shestakova, A., Vanhala, R., Alku, P., Naatanen, R., and Yaguchi, K. (2003). Speechsound- selective auditory impairment in children with autism: They can perceive but do not attend. *Proceedings of the National Academy of Sciences*, 100, 5567–5572.

Chakrabarti, S., and Fombonne, E. (2005). Pervasive developmental disorders in preschool children: confirmation of high prevalence. *American Journal of Psychiatry*, 162, 1133–1141.

Chevallier, C., Noveck, I., Happé, F., and Wilson, D. (2009). From acoustics to grammar: Perceiving and interpreting grammatical prosody in adolescents with Asperger Syndrome. *Research in Autism Spectrum Disorders*, 3, 502–516.

Chevallier, C., Noveck, I., Happé, F., and Wilson, D., (2011). What's in a voice? Prosody as a test case for the Theory of Mind account of autism. *Neuropsychologia*, 49 (3), 507–517.

Chevallier, C., Wilson, D., Happé, F., and Noveck, I. (2010). Scalar inferences in autism spectrum disorders. Journal of Autism and Developmental Disorders, 40(9), 1104–1117

Chomsky, N. (1972). *Studies on Semantics in Generative Grammar*. Mouton, The Hague.

Chomsky, N. (1976). Conditions on Rules of Grammar, *Linguistic Analysis* 2,303-351.

Chomsky, N., and Lasnik, H. (1977). Filters and control. *Linguistic Inquiry* 8. 425-504.

Christophe, A., Guasti, T., Nespor, M., Dupoux, E., and Van Ooyen, B. (1997). Reflections on phonological bootstrapping: Its role for lexical and syntactic acquisition. Language and Cognitive Processes, 12, 585– 612.

Cohen, E. (2009). *The Role of Similarity in Phonology: Evidence from Loanword Adaptation in Hebrew*. Ph.D. dissertation, Tel-Aviv University.

Cohen, G. (1989). *Memory in the real world*. Hove, UK: Lawrence Erlbaum Associates.

Collet, L., RogeÂ, B., Descouens, D., Moron, P., Duverdy, F. and Urgell, H. (1993). Objective auditory dysfunction in infantile autism. The Lancet, 342, 923-924.

Colston, H. L., and Gibbs, R. W. (2002). Are irony and metaphor understood differently? *Metaphor and Symbol, 17*, 57-60.

Crawford, J. R., and Garthwaite, P. H. (2002). Investigation of the single case in neuropsychology: Confidence limits on the abnormality of test scores and test score differences. *Neuropsychologia,* 40, 1196 –1208

Crawford, J. R., Howell, D. C. (1998). Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist* 12:482–6

Cruttenden, A. (1997). *Intonation*, 2nd ed. Cambridge University Press, Cambridge.

Crystal, D. (1986). Prosodic development. In P. Fletcher & M. Garman (Eds.), *Language acquisition (pp. 33–48).* Cambridge: Cambridge University Press.

Cutler, A., Dahan, D., and van Donselaar, W. (1997). Prosody in the comprehension of spoken language: A review. *Language and Speech*, 40, 141-201.

Davies, C., and Katsos, N. (2010). Over-informative children: Production/comprehension asymmetry or tolerance to pragmatic violations? *Lingua*, 120 (8). 1956 - 1972. ISSN 0024-3841

Dawson, G., Webb, S. J. and McPartland, J. **(2005)**. Understanding the nature of face processing impairment in autism: insights from behavioral and electrophysiological studies. *Dev. Neuropsychol*. 27, 403–424

Diehl, J., Bennetto, L., Watson, D., Gunlogson, C., and McDonough, J., (2008). Resolving ambiguity: a psycholinguistic approach to understanding prosody processing in high functioning autism. Brain and Language 106 (2), 144–152.

Diehl, J., Watson, D., Bennetto, L., Mcdonough, J., and Gunlogson, C. (2009). An acoustic analysis of prosody in high-functioning autism. *Applied Psycholinguistics.* 30(3), 385–404

Dockrell, J. E., and Messer, D. (2007). Language profiles and naming in children with word finding difficulties. *Folia Phoniatrica et Logopaedica*, 59, 318–323.

Emmorey, K. (1987). The neurological substrates for prosodic aspects of speech. *Brain and Language, 30*, 305–320.

Erwin, R. J., Van Lancker, D., Guthrie, D., Schwafel, J., Tanguay, P., and Buchwald, J. S. (1991). P3 responses to prosodic stimuli in adult autistic subjects. *Electroencephalography and Clinical Neurophysiology*, 80, 561–571.

Fattal I., Friedmann N., and Fattal-Valevski A. (2011). The crucial role of thiamine in the development of syntax and lexical retrieval: A study of infantile thiamine deficiency. *Brain* 134, 1720–1739.

Fay, W. H., and Schuler, A. L. (1980). *Emerging language in autistic children*. London: Edward Arnold.

Fine, J., Bartolucci, G., Ginsberg, G., and Szatmari, P. (1991). The use of intonation to communicate in pervasive developmental disorders. *Journal of Child Psychology and Psychiatry*, 32, 771–782

Fombonne, E. (2007). Epidemiological surveys of pervasive developmental disorders. In F. E. Volkmar (Ed.), *Autism and pervasive developmental disorders*, 2nd ed., pp. 36-68. Cambridge University Press.

Fosnot, S. M., and Jun, S. (1999). Prosodic characteristics in children with stuttering or autism during reading and imitation. In J.J. Ohala & Y. Hasegawa (Eds.), Proceedings of the 14th International Congress of Phonetic Sciences. (pp. 1925–1928). Dordrecht: Foris

Foss, D. and Ross, J. (1983). Great expectations: context effects during sentence processing. In G. Flores D'Arcais and R. Jarvella (Eds.): *The process of language understanding*. Chichester: Wiley. 169-191

Fox, D., and Katzir, R. (2011). On the characterization of alternatives. *Natural Language Semantics*. 19(1). 87–107.

Frazier, L., Carlson, K., and Clifton, C. (2006). Prosodic phrasing is central to language comprehension. *Trends in Cognitive Sciences.* 10, 244–249.

Freitag, C. M. (2007). The genetics of autistic disorders and its clinical relevance: a review of the literature. Molecular Psychiatry 12: 2–22

Freitag, C. M., Staal, W., Klauck, S. M., Duketis, E., and Waltes, R. (2010). Genetics of autistic disorders: review and clinical implications. *Eur Child Adolesc Psychiatry*, 19:169 –178.

Friedmann N. (2007). Young children and A-chains: the acquisition of Hebrew unaccusatives. *Language Acquisition*, 14: 377–422.

Friedmann, N., Biran, M., and Dotan, D. (2013). Lexical retrieval and its breakdown in aphasia and developmental language impairment. In C. Boeckx, and K. K. Grohmann (Eds.), *The Cambridge handbook of biolinguistics*, 350-374. Cambridge: Cambridge University Press

Friedmann, N., and Gvion, A. (2003). Sentence comprehension and working memory limitation in aphasia: A dissociation between semantic and phonological encoding. *Brain and Language*, 86, 23-39.

Friedmann N., Kerbel N., and Shvimer L. (2010). Developmental attentional dyslexia. *Cortex*, 46(10), 1216–1237

Friedmann, N. and Lavi, H. (2006). On the order of acquisition of A-movement, Wh-movement and V-C movement. In A. Belletti, E. Bennati, C. Chesi, E. Di Domenico and I. Ferrari (Eds), *Language acquisition and development* (pp. 211–217). Cambridge: Cambridge Scholars Press/CSP

Friedmann N., and Lukov L. (2008). Developmental surface dyslexias. *Cortex*, 44, 1146-1160.

Friedmann, N., and Novogrodsky, R. (2008). Subtypes of SLI: SYSLI, PHOSLI, LESLI and PRASLI. In A. Gavarro, and M. J. Freitas (Eds.), *Language acquisition and development* (pp. 205-217). Newcastle: Cambridge Scholars Publishing.

Friedmann N, Novogrodsky R. (2011). Which questions are most difficult to understand? The comprehension of Wh questions in three subtypes of SLI. *Lingua*, 121, 367–82.

Friedmann, N., and Szterman, R. (2006). Syntactic movement in orally trained children with hearing impairment. *Journal of Deaf Studies and Deaf Education,* 11, 56-75.

Friedmann, N., Yachini, M., and Szterman, R. (2015). Relatively easy relatives: Children with syntactic SLI avoid intervention. In E. Do Domenico, C. Hamann, and S. Matteini (Eds.), Structures, strategies and beyond, Studies in honor of Adriana Belletti (pp. 303-320). Amsterdam, The Netherlands: John Benjamins, Linguistik Aktual series

Frith, U. (1989). *Autism: explaining the enigma*. Oxford: Basil Blackwell.

Frith, U. (1991). Translation and annotation of "autistic psychopathy" in childhood by H. Asperger. In U. Frith (Ed.), *Autism and Asperger syndrome* (pp. 37-92). Cambridge: Cambridge University Press.

Gazdar, G. (1979). *Pragmatics: Implicature, Presupposition, and Logical Form*, Academic Press, NY.

Gerken, L. (1996). Prosody's role in language acquisition and adult parsing. *Journal of Psycholinguistic Research,* 25, 345-356

Gerken, L., and McGregor, K. (1998). An overview of prosody and its role in normal and disordered child language. *American Journal of Speech-Language Pathology,7(2),* .48–38

German, J., Pierrehumbert, J., and Kaufmann, S. (2006). Evidence for phonological constraints on nuclear accent placement. *Language*, 151-168.

Ghaziuddin M., and Gerstein, L. (1996). Pedantic speaking style differentiates Asperger syndrome from high-functioning autism. *Journal of Autism and Developmental Disorders, 26*(6), 585–595.

Ghaziuddin, M., Thomas, P., Napier, E., Kearney, G., Tsai, L., Welch, K. and Fraser, W. (2000). Brief report: Brief syntactic analysis in Asperger syndrome: A preliminary study. *Journal of Autism and Developmental Disorders,* 30(1), 67-70.

Gillberg, C., (1991), Clinical and neurobiological aspects of Asperger syndrome in six family studies. In U. Frith (Ed.), *Autism and Asperger Syndrome* (pp. 122-146). Cambridge: Cambridge University Press.

Gillberg, C. (2002). *A guide to Asperger syndrome*. Cambridge University Press.

Gillberg, C., and Billstedt, E. (2000). Autism and Asperger syndrome: Coexistence with other clinical disorders. *Acta Psychiatrica Scandinavica, 102*(5), 321-330.

Gillberg, C., and Coleman M. (2000). The Biology of the Autistic Syndromes. 3rd ed. London, UK: Mac Keith Press, Distributed by Cambridge University Press.

Giora, R. (2003). *On Our Mind: Salience, Context, and Figurative Language.* New York: Oxford University Press.

Giora R., Gazal O., Goldstein I., Fein O., and Stringaris A. (2012). Salience and Context: Interpretation of Metaphorical and Literal Language by Young Adults Diagnosed with Asperger's Syndrome. *Metaphor and Symbol*. 27(1):22-54.

Gleitman, L., Gleitman, H., Landau, B., and Wanner, E. (1988). Where the learning begins: Initial representations for language learning. In F. Newmeyer, (ed.), *The Cambridge Linguistic Survey*, vol. 3. Cambridge, MA: Harvard University Press.

Gleitman, L., and Wanner, E. (1982). The state of the state of the art. In E. Wanner and L. Gleitman, (eds.), *Language acquisition: The state of the art*. Cambridge: Cambridge University Press.

Golan, O., Baron-Cohen, S., Hill, J. J., and Rutherford, M. D. (2007). The 'Reading the Mind in the Voice' test-revised: A study of complex emotion recognition in adults with and without autism spectrum conditions. *Journal of Autism and Developmental Disorders*, 37(6), 1096–1106.

Gomot, M., Giard, M.H., Adrien, J.L., Barthelemy, C., and Bruneau, N. (2002). Hypersensitivity to acoustic change in children with autism: electrophysiological evidence of left frontal cortex dysfunctioning. *Psychophysiology.* Sep; 39(5):577-84.

Gotzner, N., Spalek, K., and Wartenburger, I. (2013). How pitch accents and focus particles affect the recognition of contextual alternatives. In M. Knauff, M. Pauen, N. Sebanz, and I. Wachsmuth (Eds.), *Proceedings of the 35th annual meeting of the cognitive science society* (p. 2434- 2440). Austin, TX: Cognitive Science Society.

Grandin, T. (1992). *An inside view of autism*. In E. Schopler and G.B. Mesibov (Eds.), High-functioning individuals with autism (pp. 105–126). New York: Plenum.

Grice, P. (1975). Logic and conversation. In P. Cole and J.L. Morgan (Eds.), Studies in syntax. Vol 3: Speech acts (pp. 41–58). New York: Academic Press.

Gross, D., and Harris, P. (1988). Understanding false beliefs about emotion. International Journal of Behavioral Development, 11, 475–488.

Grossman, R. B., Bemis, R. H., Skwerer, D. P., and Tager-Flusberg, H. (2010). Lexical and affective prosody in children with high-functioning autism. *Journal of Speech, Language and Hearing Research* 53, 778–793.

Gussenhoven, C. (1992). Sentence accents and argument structure. In I.M. Roca (Ed.), *Thematic structure. Its role in grammar*, (pp. 79-106). Berlin-New York: Foris

Gussenhoven, C. (1999). On the limits of focus projection in English. In P. Bosch and R. van der Sandt (Eds.), *Focus: Linguistic, Cognitive and Computational Perspectives*, pp. 43–55. Cambridge UK: Cambridge University Press.

Gussenhoven C. (2007). Types of focus in English. In: C Lee, M Gordon and D Büring, editors. *Topic and Focus: Cross-linguistic Perspectives on Meaning and Intonation*, New York: Springer. *83-100*.

Gvion, A., and Friedmann, N. (2007). Is phonological working memory involved in sentence comprehension? The difference between phonological and semantic reactivation. In Y. Falk (Ed.), Proceedings of the 23th IATL conference.

Gvion, A., and Friedmann, N. (2008). *FriGvi*: *Friedmann Gvion battery for assessment of phonological Working Memory*. *Language and Brain*, *7*, 161-180.

Hajičová, E., Partee, B., and Sgall, P. (1998). *Topic-Focus Articulation, Tripartite Structures, and Semantic Content*. Kluwer, Dordrecht.

Hall, G. B., Szechtman, H., and Nahmias, C. (2003). Enhanced salience and emotion recognition in autism: A PET study. *American Journal of Psychiatry*, 160, 1439–1441.

Halliday, M. (1967). Notes on transitivity and theme in English, Part II. Journal of Linguistics 3, 199-244

Hamblin, C. L., (1973). Questions in Montague English. Foundations of Language 10:4 1-53.

Happé, F. (1993). Communicative competence and theory of mind in autism: a test of relevance theory. *Cognition, 48*(2), 101-119.

Happé, F. (1999). Autism: Cognitive deficit or cognitive style? *Trends in Cognitive Sciences*, 3, 216–222

Hayes, R. W., and Gordon, A. G. (1977). Auditory abnormalities in autistic children. *The Lancet*, 2, 767.

Heilman, K., Bowers, D., Speedie, L., and Coslett, H. (1984). Comprehension of affective and nonaffective prosody. *Neurology, 34*, 917–921.

Herburger, E. (2000). *What Counts: Focus and Quantification*. Linguistic Inquiry Monographs 36. Cambridge, MA: The MIT Press.

Hill, E. (2004). Evaluating the theory of executive dysfunction in autism. *Developmental Review*, 24, 189–233.

Hirotani, M., Frazier, L., and Rayner, K. (2006). Punctuation and intonation effects on clause and sentence wrap-up: Evidence from eye movements. *Journal of Memory and Language*, 54, 425–443.

Hirsh-Pasek, K., Kemler Nelson, D.G., Jusczyk, P.W., Wright Cassidy, K., Druss, B., and Kennedy, L. (1987). Clauses are perceptual units for young infants. *Cognition* 26, 269-286.

Hobson, R. P., Ouston, J. and Lee, A. (1988) What's in a face? The case of autism. *British Journal of Psychology* 79, 441–53

Horn, L. R. (1972). On the semantic properties of logical operators in English. University of California: LA.

Hubbard K., Trauner D.A. (2007). *Intonation and emotion in autistic spectrum disorders*. Journal of Psycholinguist Research, 36, 159-173.

Hughes, C., Russell, J., and Robbins, T. W. (1994). Evidence for executive dysfunction in autism. *Neuropsychologia*, 32, 477–492

Husband, M., and Ferreira, F. (2012). Generating contrastive alternatives: Activation and suppression mechanisms. Paper presented at the CUNY Conference on Human Sentence Processing. The Graduate Center of the City University of New York.

Ito, K., and Speer, S. (2008). Anticipatory effects of intonation: Eye movements during instructed visual search. *Journal of Memory and Language*, 58, 541573.

Jackendoff, R. (1972). *Semantic Interpretation in Generative Grammar*. Cambridge, MA: The MIT Press.

Jansson-Verkasalo, E., Čeponiene, R., Kielinen, M., Suominen, K., Jäntti, V., Linna, S.-L., et al. (2003). Deficient auditory processing in children with Asperger syndrome, as indexed by event-related potentials. *Neuroscience Letters*, 338, 197–200.

Kadmon, N. (2001). *Formal pragmatics: Semantics, pragmatics, presupposition, and focus*. Oxford: Blackwell.

Kanner L. (1943). Autistic disturbance of affective contact. *Nervous Child*, 2, 217-250.

Kanner, L. (1971). Follow-up study of eleven autistic children originally reported in 1943. *Journal of Autism and Childhood Schizophrenia*, 1, 119-145.

Karttunen, L. (1977). Syntax and Semantics of Questions. *Linguistics and Philosophy* 1, 3-44.

Katzir, R. (2007). Structurally-defined alternatives. Linguistics and Philosophy 30(6). 669–690

Kemner C., Verbaten M. N., Cuperus J.M., Camfferman G. and van Engeland H. (1995). Auditory event-related brain potentials in autistic children and three different control groups. *Biological Psychiatry*, 38(3), 150-65.

Kent, R., and Read, C. (1992). *The acoustic analysis of speech.* San Diego: Singular Publishing Group.

Klin, A. (1993). Auditory brainstem responses in autism: brainstem dysfunction or peripheral hearing loss? *Journal of Autism and Developmental Disorders*, 23, 15–35.

Klin, A., and Volkmar, F.R. (1997). Asperger syndrome. In D. J. Cohen & F. R. Volkmar (Eds.), Handbook of autism and pervasive developmental disorders, 2nd ed., pp. 94–122. New York: Wiley.

Klin, A., Sparrow, S., and Volkmar, F.R. (2000). *Asperger syndrome*. New York: The Guilford Press. 489

Koegel, R. L., and Schreibman, L. (1976). Identification of consistent responding to auditory stimuli by a functionally "deaf" autistic child. *Journal of Autism and Developmental Disorders*, 6, 147-156.

Krifka, M. (2006). Association with focus phrases. In: Valeria Molnár and Susanne Winkler (eds): *The architecture of focus*, 105–136. Mouton de Gruyter, Berlin & New York.

Krifka, M. (2007). Basic notions of information structure. In C. Fery and M. Krifka (eds.), *Interdisciplinary Studies of Information Structure*. 6. Potsdam: Universität Potsdam

Kujala, T., Lepistö, T., Nieminen-von Wendt, T., Näätänen, P. and Näätänen, R. (2005). Neurophysiological evidence for cortical discrimination impairments of prosody in Asperger syndrome. *Neuroscience Letters*, 383, 260–266.

Ladd, D. R. (1980). *The structure of intonational meaning: evidence from English*. Bloomington: Indiana University Press.

Ladd, D. R. (1996). *Intonational Phonology*. Cambridge University Press, Cambridge.

Landa, R. (2000). Social language use in Asperger's syndrome and high-functioning autism. In A. Klin, F. R. Volkmar, and S. S. Sparrow (Eds.), *Asperger's syndrome* (pp. 125–155). New York: Guilford Press.

Le Couteur, A., Lord, C., and Rutter, M. (2003). The Autism Diagnostic Interview-Revised (ADI-R). Los Angeles, CA: Western Psychological Services.

Lehiste, I. **(1970).** *Suprasegmentals*. Cambridge, MA:MIT press.

Levelt, W. J. M., Praamstra, P., Meyer, A. S., Helenius, P., and Salmelin, R. (1998). An MEG study of picture naming. *Journal of Cognitive Neuroscience*, 10, 553–567

Lindner, J. L., and Rosen, L. A. (2006). Decoding of emotion through facial expression, prosody and verbal content in children and adolescents with Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 36(6), 769–777.

Lord, C., Rutter, M., and Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 24, 659–685.

Lord, C., Rutter, M., and DiLavore, P. (1996). Autism diagnostic observation schedule. Unpublished manuscript, University of Chicago.

Lord, C., Rutter, M., DiLavore, P., and Risi, S. (1999). The ADOS-G (Autism Diagnostic Observation Schedule- Generic). Los Angeles: Western Psychological Services.

Loukusa, S., and Moilanen, I. (2009). Pragmatic inference abilities in individuals with Asperger syndrome or high-functioning autism. A review. *Research in Autism Spectrum Disorders*, 3, 890–904.

Luks, T., Nusbaum, H., and Levy, J. (1998). Hemispheric involvement in the perception of syntactic prosody is dependent on task demands. *Brain and Language, 65*, 313–332

Lust, B., Flynn S., and Foley C. (1996). What children know about what they say: elicited imitation as a research method for assessing children's syntax. In: McDaniel D, McKee C, Cairns H, editors. Methods for assessing children's syntax. Cambridge, MA: MIT Press. p. 55–76.

Martin, I., and McDonald, S. (2004). An exploration of causes of non-literal language problems in individuals with Asperger Syndrome. *Journal of Autism and Developmental Disorders.* 34, 311–328.

Mattila, M. L., Kielinen, M., Jussila, K., Linna, S. L., Bloigu, R., Ebeling, H., and Moilanen, I. (2007). An epidemiological and diagnostic study of asperger syndrome according to four sets of diagnostic criteria. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*(5), 636-645.

Mayes, S. D., and Calhoun, S. L. (2001). Non-significance of early speech delay in children with autism and normal intelligence and implications for DSM-IV Asperger's disorder. *Autism*, 5, 81–94.

McAteer, E., (1992). Typeface emphasis and information focus in written language. *Applied Cognitive Psychology.* 1992;6:345–359

McCann, J., and Peppé, S. (2003). Prosody in autistic spectrum disorders: A critical review. *International Journal of Language and Communication Disorders*, 38, 325-350.

McCann, J., Peppé, S., Gibbon, F. E., O'Hare, A., and Rutherford, M. (2007). Prosody and its relationship to language in school-aged children with high-functioning autism. *International Journal of Language and Communication Disorders*, 42, 682–702.

McCaleb, P., and Prizant, B. (1985). Encoding of new versus old information by autistic children. *Journal of Speech and Hearing Disorders*, 50, 230–240.

Merewether, R., and Alpert, M. (1990). The components and neuroanatomic bases of prosody. *Journal of Communication Disorders,* 23, 325–336

Morgan, J. L., and Demuth, K. (Eds.) (2014). *Signal to syntax: Bootstrapping from speech to grammar in early acquisition*. Mahwah, NJ: Erlbaum.

Mottron, L., Dawson, M., Soulieres, I., Hubert, B., and Burack, J. (2006). Enhanced perceptual functioning in autism: An update, and eight principles of autistic perception. *Journal of autism and developmental disorders*, 36(1), 27-43.

Murphy D,. and Cutting J. (1990). Prosodic comprehension and expression in schizophrenia. *J Neurol Neurosurg Psychiatry*. 53(9):727–730.

Neil, W.T. (1977). Inhibition and facilitation processes in selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, 3, 444–450.

Nieuwland, M., Ditman, T., and Kuperberg, G. (2010). On the incrementality of pragmatic processing: An ERP investigation of informativeness and pragmatic abilities. *Journal of Memory and Language,* 63, 324-346.

Norbury, C.F. (2005). Barking up the wrong tree: Lexical ambiguity resolution in children with language impairments and autism spectrum disorders. *Journal of Experimental Child Psychology,* 90, 142-171.

Norris, D., Cutler, A., McQueen, J., Butterfield, S. (2006). Phonological and conceptual activation in speech comprehension. *Cognitive Psychology,* 53, 146-193.

Novogrodsky, R., and Friedmann, N. (2006). The production of relative clauses in SLI: A window to the nature of the impairment. *Advances in Speech-Language pathology,* 84, 364-375.

O'Reilly, R. C., Braver, T. S., and Cohen, J. D. (1999). A biologically-based computational model of working memory. In A. Miyake and P. Shah (Eds.). *Models of working memory: mechanisms of active maintenance and executive control* (pp. 375-411). New York: Cambridge University Press

Ozonoff, S. (1997). Components of executive function deficits in autism and other disorders. In J. Russel (Ed.), *Autism as an executive disorder* (pp. 179–211). Oxford: Oxford University Press.

Ozonoff, S., and Jensen, J. (1999). Specific executive function profiles in three neurodevelopmental disorders. *Journal of Autism and Developmental Disorders,* 29, 171–177.

Ozonoff, S., and Miller, J. (1996). An exploration of right hemisphere contributions to the pragmatic impairments of autism. Brain and Language, 52, 411-434.

Ozonoff, S., and Strayer, D.L. (2001). Further evidence for intact working memory in autism. *Journal of Autism and Developmental Disorders*, 31, 257–263.

Paccia, J., and Curcio, F. (1982). Language processing and forms of immediate echolalia in autistic children. *Journal of Speech and Hearing Research*, 25, 42–47.

Panagos, J., and Prelock, P. (1997). Prosodic analysis of child speech. *Topics in Language Disorders, 17*(4), 1–10.

Paul, R., Augustyn, A., Klin, A., and Volkmar, F. (2005). Perception and production of prosody by speakers with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, 35, 205-220.

Peppé, S., and McCann, J. (2003). Assessing intonation and prosody in children with atypical language development: The PEPS-C test and the revised version. *Clinical Linguistics and Phonetics*, 17, 345-354.

Peppé S., McCann, J., Gibbon, F., O'Hare, A., and Rutherford, M. (2006). Assessing prosodic and pragmatic ability in children with high-functioning autism. *Journal of Pragmatics*. 38:1776–1792.

Peppé S., McCann J., Gibbon J., O'Hare A., and Rutherford M. (2007) Receptive and expressive prosodic ability in children with high-functioning autism. *Journal of Speech, Language, & Hearing Research* 50:1015–1028

Peters, A. (1983). *The units of language acquisition.* Cambridge, England: Cambridge University Press.

Pierrehumbert, J., and Hirschberg, J. (1990). The meaning of intonational contours in the interpretation of discourse. In Cohen, P. R., Morgan, J., and Pollack, M. E., (eds.), *Intentions in Communication,* (pp. 271–311). MIT Press, Cambridge.

Pijnacker, J., Hagoort, P., Buitelaar, J., Teunisse, J., and Geurts, B. (2009). Pragmatic inferences in high-functioning adults with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders*, 39, 607–618.

Premack, D. G., and Woodruff, G. (1978). Does the chimpanzee have a theory of mind?. *Behavioral and Brain Sciences* 1 (4), 515–526.

Prince A., and Smolensky, P. (1993), *Optimality Theory: Constraint Interaction in Generative Grammar*, RuCCS Technical Report, Rutgers University Center for Cognitive Science.

Rajendran, G., and Mitchell, P. (2007). Cognitive theories of autism. *Developmental Review*, 27, 224–260.

Ramberg, C., Ehers, S., Nyden, A., Johansson, M., and Gillberg, C. (1996). Language and pragmatic functions in school-age children on the autism spectrum. *European Journal of Disorders of Communication*, 31, 387–414.

Roach, P. (2000). *English phonetics and phonology*. Cambridge: CUP.

Rooth, M. (1985). *Association with Focus*, PhD dissertation, University of Massachusetts at Amherst. Published by GLSA, Department of Linguistics, University of Massachusetts at Amherst.

Rooth, M. (1992). A Theory of Focus Interpretation, *Natural Language Semantics* 1, 75–116.

Rooth, M. (1996). On the Interface Principles for Intonational Focus, in T. Galloway and J. Spence (eds.), Proceedings from SALT 6, pp. 202–226. Cornell University, Ithaca, N.Y.

Rooth, M. (1999). Association with Focus or Association with Presupposition? In Bosch, P. and van der Sandt R. (eds.), *Focus - Linguistic, Cognitive, and Computational Perspectives*. Cambridge University Press.

Rosenhall, U., Nordin, V., Sandstroem, M., Ahlsen, G., and Gillberg, C. (1999). Autism and hearing loss. *Journal of Autism and Developmental Disorders*, 29, 349–357.

Rutherford, M. D., Baron-Cohen, S., and Wheelwright, S. (2002). Reading the Mind in the Voice: A Study with Normal Adults and Adults with Asperger Syndrome and High Functioning Autism. *Journal of Autism and Developmental Disorders, 32*(3), 189-194.

Russell, J., Jarrold, C., and Henry, L. (1996). Working memory in children with autism and with moderate learning difficulties. *Journal of Child Psychology and Psychiatry*, 37, 673–686.

Rutter, M., and Lockyer, L. (1967). A five to fifteen year follow-up study of infantile psychosis. I. Description of the sample. *British Journal of Psychiatry*, 113, 1169-1182.

Sanford, A. and Garrod, S. (1998). The role of scenario mapping in text comprehension. *Discourse Processes* 26, 159-190.

Sanford, A. and Sturt, P. (2002). Depth of processing in language comprehension: Not noticing the evidence. *Trends in Cognitive Sciences* 6, 382-386.

Schmerling, S. F. (1974). A re-examination of normal stress. *Lingua* 50. 66-73

Schopler, E. (1998). Premature popularization of Asperger syndrome. In E. Schopler, G. B. Mesibov, and L. J. Kunce (Eds.), *Asperger syndrome or high-functioning autism?* (pp. 385–399). New York: Plenum Press.

Schwarzschild, R. (1999). GiVENness, AvoidF and Other Constraints on the Placement of Accent, *Natural Language Semantics* 7(2), 141–177.

Selkirk, E. (1984). *Phonology and Syntax. The Relation between Sound and Structure.* Cambridge, MA: MIT Press.

Selkirk, E. (1986). On Derived Domains in Sentence Phonology. *Phonology Yearbook* 3, 371-405.

Selkirk, E. (1995). Sentence prosody: Intonation, stress and phrasing, in John Goldsmith (ed.), *Handbook of phonological theory*, Blackwell, Cambridge, 550–569.

Shattuck, P. T. (2006). Diagnostic substitution and changing autism prevalence. *Pediatrics*; 117:1438 –1439.

Shriberg, L., Paul, R., McSweeny, J., Klin, A., Cohen, D., and Volkmar, F. (2001). Speech and prosody characteristics of adolescents and adults with high-functioning autism and Asperger's Syndrome. *Journal of Speech, Language, and Hearing Research* 44: 1097-1115.

Simmons, J., and Baltaxe, C. (1975). Language patterns in adolescent autistics. *Journal of Autism and Childhood Schizophrenia*, 5:333–351

Snowling, M., and Frith, U. (1986). Comprehension in 'hyperlexic' readers. *Journal of Experimental Child Psychology.* 42, 392–415.

Sperber, D., and Wilson, D. (1986/1995). Relevance: Communication and cognition. Oxford: Blackwell.

Stolterfoht, B., Friederici, A., Alter, K., and Steube, A. (2007). Processing focus structure and implicit prosody during reading: Differential ERP effects. *Cognition*, 104(3), 565–590.

Stone, V. E., Baron-Cohen, S., and Knight, R. T. (1998). Frontal lobe contributions to theory of mind. *Journal of Cognitive Neuroscience,10,* 640–656.

Szatmari, P. (2000). *Perspectives on the classification of Asperger syndrome*. In A. Klin, F. R., Volkmar, and S. S. Sparrow (Eds.). Asperger syndrome (pp. 403–417). New York, Guildford Press.

Tabossi, P. (1988). Effects of context on the immediate interpretation of unambiguous nouns. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 153-162.

Tager-Flusberg, H. **(1995).** Dissociation in form and function in the acquisition of language by autistic children, in Tager-Flusberg, H. (Ed): *Constraints on Language Acquisition: Studies of Atypical Children*. Hillsdale, NJ, Lawrence Erlbaum, 1994, pp 175-194

Tager–Flusberg, H. (1999). A psychological approach to understanding the social and language impairments in autism. *International Review of Psychiatry*, 11, 325–334.

Tager-Flusberg, H. (2007). Evaluating the theory-of-mind hypothesis of autism. *Current Directions in Psychological Science*, 16, 311–315.

Tantam, D., Monoghan, L., Nicholson, H., and Stirling, J. (1989). Autistic children's ability to interpret faces: A research note. *Journal of Child Psychology and Psychiatry*, 30, 623–630.

Taylor, B. (2006). Vaccines and the changing epidemiology of autism. *Child Care Health Development*, 32, 511–519.

Thurber, C., and Tager-Flusberg, H. (1993). Pauses in the narrative produced by autistic, mentally retarded, and normal children as an index of cognitive demand. *Journal of Autism and Developmental Disorders*, 23, 309–322.

Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *Quarterly Journal of Experimental Psychology Human Experimental Psychology A*, 37, 571–590.

Truckenbrodt, H. (1999). On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30:219-255.

Volkmar, F. R., and Klin, A. (2000). *Diagnostic issues in Asperger syndrome*. In A. Klin, F. R. Volkmar, and S. S. Sparrow (Eds.), Asperger syndrome (pp. 25–71). New York: Guilford.

Warren, P. (1996). Parsing and prosody: An introduction. In P. Warren (Ed.), *Prosody and parsing,* 1–16. East Sussex, UK: Psychology Press.

Weber, A., Braun, B., and Crocker, M. (2006). Finding referents in time: Eye-tracking evidence for the role of contrastive accents. *Language and Speech*, 49, 367392

Wechsler, D. (1997). *WAIS-III administration and scoring manual*. San-Antonio: Harcourt Brace & Company.

Weeks S.J. and Hobson R.P. (1987). The salience of facial expression for autistic children. *Journal of Child Psychology and Psychiatry*, 28, 137–151

Wellman, H. M., Cross, D. and Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development,* 72, 655–684.

Wells, B., and Peppé, S. (2003). Intonation abilities of children with speech and language impairments. *Journal of Speech, Language and Hearing Research* 46, 5-21.

Wells, B., Peppé, S., and Goulandris, A. (2004). Intonation development from five to thirteen. *Journal of Child Language*, 31, 749-778.

Willis, C. S., and Gathercole, S. E. (2001). Phonological short-term memory contributions to sentence processing in young children. *Memory*, 9, 349–364.

Wilson, D. and Sperber D. (1988). Representation and relevance. In R. Kempson (ed.). *Mental Representation: The Interface between Language and Reality*. 133-53. Cambridge: Cambridge University Press

Wilson, D., and Wharton, T. (2006). Relevance and prosody. *Journal of Pragmatics*, 38, 1559–1579.

Wimmer, H., and Perner, J. (1983). Beliefs about beliefs—representation and constraining function of wrong beliefs in young childrens understanding of deception. *Cognition*, 13(1), 103–128.

Wing, L. (1981). Asperger syndrome: A clinical account. *Psychological Medicine*, 11, 115-129.

Wing, L. (1997). The history of ideas on autism: Legends, myths and reality. *Autism*, 1, 13–24.

Wing, L. (1998). The history of Asperger syndrome. In E. Schopler, G.B. Mesibov, & L.J. Kunce (Eds.), *Asperger syndrome or high-functioning autism?* (pp. 11–28). New York: Plenum Press.

Wing, L., and Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. *Journal of Autism and Developmental Disorders* 9: 11–29.

Wold, D. (1996). Long distance selective binding: The case of focus, *Proceedings of SALT VI*, CLC Publications, Ithaca, 311–328.

World Health Organization. (1993). ICD-10 Classification of Mental and Behavioural Disorders: Diagnostic criteria for research. World Health Organization.

Xiang, M., Giannakidou, A., and Grove, J. (2012). Two stages of NPI licensing: an ERP study, Poster Presented at the 25th Annual Meeting of the CUNY Conference of Human Sentence Processing (New York, NY)

Xiang, M., Grove, J., and Giannakidou, A. (2013). Dependency dependent interference: NPI interference, agreement attraction, and global pragmatic inferences. *Frontiers in Psychology*, 4, 708.

בירן, מ., ופרידמן, נ. (2004). שמש: שיום מאה שמות עצם. אוניברסיטת תל-אביב.

בלבן, נ., פרידמן, נ., ואריאל, מ. (2007). ההשלכות השפתיות של פגיעה נרכשת ב-Theory of Mind. שפה ומוח, 6, 43-54. אוניברסטת תל אביב.

יוסף סוקניק, נ. (2012). הקשר בין הבנה לבין יכולת הקריאה ברמת מילה, משפט וקטע אצל ילדים עם אוטיזם. עבודה לקראת תואר 'מוסמך במדעי הרוח'. החוג לחינוך מיוחד וייעוץ חינוכי. אוניברסיטת תל אביב

פרידמן, נ. (1998). בפלא: בטרית פרידמן לאגרמטיזם. אוניברסיטת תל-אביב.

פרידמן, נ. (2000). פטל: פרידמן טסט לחזרה. אוניברסיטת תל-אביב.

פרידמן, נ, .וגביעון, א. (2003). תלתן :בטריה לאבחון דיסלקסיות .אוניברסיטת תל אביב.

פרידמן, נ., ונובוגרודסקי ,ר. (2002). במבי :בטרית מבחנים בתחביר ילדים .אוניברסיטת תל אביב.

שטרמן, ר., (2003). *הבנה של משפטים עם תנועה תחבירית אצל ילדים לקויי שמיעה* .עבודת גמר לקראת התואר מוסמך ,מדעי הרוח ,מגמה לחינוך מיוחד ,תוכנית חינוך תלמידים לקויי שמיעה ,אוניברסיטת תל אביב.

תקציר

ילדים ובוגרים המאובחנים על הקשת האוטיסטית מבטאים לעתים קשיים הקשורים בפרוזודיה של הדיבור. קשיים אלו צוינו כמאפיין בולט של התסמונות האוטיסטיות עוד בדיווחיהם המוקדמים של Kanner (1943) ושל Asperger (1944) במחצית הראשונה של המאה הקודמת.

הממצאים הנוגעים ללקויות פרוזודיות בקרב אוכלוסיית האוטיסטים אינם חד-משמעיים בתאור מאפייני הלקות ובהגדרת תפוצתה, ובכל זאת, קיימת הסכמה לפיה קשיים בהפקת פרוזודיה משפיעים באופן משמעותי על יכולתם של האוטיסטים להבנות אינטראקציה חברתית תקינה. על אף הבנה זו, מהות הליקויים הפרוזודיים, היקפם ומקורם עדיין אינם ברורים, ולא מספיק ידוע על הקשר בין ליקויים אלו ובין היבטים של תפיסת פרוזודיה, כמו גם על הממשק האפשרי של הלקות הפרוזודית עם יכולות קוגניטיביות ולשוניות אחרות, כגון מיומנויות פרגמטיות והתאוריה של התודעה (Theory of Mind).

המחקר הנוכחי מתמקד בתפיסת פרוזודיה בקרב קבוצה של בוגרים, דוברי עברית, המאובחנים בתסמונת אספרגר, ומטרתו של המחקר להעריך האם הנבדקים תופסים ומעבדים מידע פרוזודי באופן שונה, בהשוואה לנבדקים ללא התסמונת. יתר על כן, המחקר משווה את ביצועי קבוצת האספרגר בזיהוי ובעיבוד דפוסים פרוזודיים הנבדלים בתפקידם בשפה - פרוזודיה דקדוקית, פרוזודיה פרגמטית (לשונית) ופרוזודיה רגשית.

עדויות ממחקרים אשר בחנו לקויות פרוזודיות בקרב נבדקים עם פגיעות מוחיות, כמו גם במגוון אוכלוסיות אחרות, מצביעות על כך שהפונקציות הפרוזודיות השונות הן עצמאיות במידה מסוימת, ועשויות להפגע בנפרד זו מזו. ממצאי מחקרים בהם השתתפו נבדקים המאובחנים על הקשת האוטיסטית, מבטאים מגמה לפיה בקרב אוכלוסיית האוטיסטים, קשיים פרוזודיים צפויים להתעורר בעיקר כאשר הפרוזודיה משמשת בתפקיד פרגמטי או רגשי, בעוד שפונקציות דקדוקיות של הפרוזודיה צפויות להוותר תקינות (Shriberg et al. 2001, Paul et al. 2005, Kujala et al. 2005, Chevalier et al. 2009).

במחקר הנוכחי נבדקה קבוצה של עשרה משתתפים עם תסמונת אספרגר (גיל ממוצע: 30;4, סטיית תקן: 4.2) וקבוצת ביקורת של שלושים משתתפים ללא התסמונת (גיל ממוצע: 25;1, סטיית תקן: 4.0). המחקר כלל בטריה של 16 מטלות פרוזודיות, אשר נועדו להעריך את יכולת

המשתתפים לזהות ולעבד דפוסים פרוזודיים שונים, המבטאים פונקציות פרוזודיות שונות בשפה. על מנת לבודד את משתנה הפרוזודיה ולבחון ממשקים אפשריים בין לקות פרוזודית ובין יכולות שפתיות וקוגניטיביות אחרות, המשתתפים נמדדו גם במטלות של Theory of Mind, קיבולת זיכרון עבודה, יכולת תחבירית ולקסיקלית, יכולת קריאה ומיומנויות פרגמטיות.

תוצאות המחקר מצביעות על חסר משמעותי בהיבט הפרגמטי-לשוני של תפיסת פוקוס. חסר זה אפיין את רוב המשתתפים בקבוצת האספרגר (8 מתוך 10 משתתפים). קשיים בהיבטים הדקדוקיים והרגשיים של הפרוזודיה נמצאו כפחות עקביים ואפיינו רק ארבעה מהמשתתפים. כמו-כן, קשיים אלו נמצאו בהתאמה עם אינטליגנציה מילולית נמוכה יותר (Verbal IQ), עם ירידה בזיכרון העבודה ועם ביצועים נמוכים יחסית במבדקים שפתיים שאינם פרוזודיים.

ממצאי המחקר נדונים לאור המאפיינים הייחודיים של מבני פוקוס ומנגנוני הפירוש והעיבוד של פוקוס. ניתוח הממצאים מציע כי הקושי המשותף לקבוצת האספרגר עשוי לנבוע מפגיעה סלקטיבית באופרציות עיבוד פוקוס, המערבות הנגשת אלטרנטיבות לרכיב המפוקס. ממצאי המחקר מדגישים את השונות ואת ההבדלים האינדיבידואלים בין המשתתפים ומצביעים על התחום הפרוזודי הספציפי בו נדרשים המשתתפים מקבוצת האספרגר לסיוע. בכך עשויים הממצאים לסייע באבחון ולקדם תכניות טיפול. בנוסף, ממצאי המחקר מחזקים את הטענה לפיה הפרוזודיה אינה מהווה מקשה אחת. הפרוזודיה מתבטאת ברבדים רבים של השפה והיבטים פרוזודיים שונים עשויים להפגע באופן עצמאי זה מזה ולהשפיע בצורה שונה על הכשירות הפרוזודית של הנבדקים.

אוניברסיטת תל-אביב
הפקולטה למדעי הרוח ע״ש לסטר וסאלי אנטין
החוג לבלשנות

ליקוי פרוזודי בתפיסת פוקוס:
עדויות מתסמונת אספרגר

חיבור זה הוגש כעבודת גמר לקראת התואר
׳מוסמך אוניברסיטה׳ (M.A.) באוניברסיטת תל-אביב

על ידי:
הדס זיידנברג

העבודה נעשתה בהנחיית:
פרופ׳ אותי בת-אל ופרופ׳ נעמה פרידמן

נובמבר 2015