RESEARCH ARTICLE

Pragmatic Language in Children and Adolescents With Autism Spectrum Disorder: Do Theory of Mind and Executive Functions Have a Mediating Role?

Ramona Cardillo, Irene C. Mammarella, Ellen Demurie, David Giofrè, and Herbert Roeyers

Pragmatic language (PL) is defined as the ability to use language effectively in communicative exchanges. Previous findings showed that deficits in PL are a core characteristic of the communicative profile of individuals with autism spectrum disorder (ASD). While different lines of research have revealed a close link between PL and theory of mind (ToM), and between PL and executive functions (EFs), to our knowledge, few studies have explored the relationship between these three domains in children with ASD, and their results have been contradictory. The present study thus aimed to contribute to our understanding of PL in children with ASD and to analyze the underlying mediating role of ToM and EFs. PL is a complex and multifaceted construct. In the present study, we focused on two specific aspects, such as the comprehension of nonliteral language, and the ability to make inferences. After testing 143 participants (73 with ASD), our results confirmed that impairments in PL are a crucial feature of the ASD profile. Children with ASD were also more impaired than their typically developing peers in both ToM and EFs. When the mediating role of ToM and EFs on PL was considered, it emerged that only ToM contributed significantly to the relationship between group and PL. We discussed the potential importance of interventions not focused exclusively on PL, but also involving ToM. ***Autism Res** 2020, 00: 1–14*. © 2020 International Society for Autism Research and Wiley Periodicals LLC.

Lay Summary: In everyday life, we use pragmatic language to interact successfully with others. Individuals with autism experience significant difficulty in pragmatic language, showing consequent impairments in communication. This study compared the comprehension of nonliteral language, and the ability to make inferences of children with autism and children with typical development, focusing on the role of social and cognitive abilities. Children with autism had difficulties in pragmatic language compared to children with typical development. In addition, the capacity to consider the perspective, intentions and beliefs of other people contributed significantly to the pragmatic language.

Keywords: pragmatic language; communication; autism spectrum disorder; theory of mind; executive functions

Introduction

In everyday life, we use language to communicate with others and to maintain interpersonal relationships. Although vocabulary and syntax rules have a fundamental role in our communicative exchanges, to interact successfully with others, we also need to consider the context and our listeners' expectations. We need to grasp information that is not explicitly stated in a sentence (e.g. metaphors, inferences, and idiomatic expressions) and to interpret nonverbal signals and nonliteral meanings. All these practical examples of everyday communication can be framed in the context of the pragmatic language (PL). Specifically, PL can be defined as the ability to use language effectively in communicative exchanges [Milligan, Astington, & Dack, 2007], an ability crucial to our interactions with peers, and our socio-emotional development [Roselló, Berenguer, Navío, Baixauli, & Miranda, 2017]. Impairments in PL can lead to communication failures and are a core characteristic of the communicative profile of individuals with autism spectrum disorder (ASD) [Colle, Baron-Cohen, Wheelwright, & van der Lely, 2008; Kim et al., 2014; Norbury & Bishop, 2002; Simmons, Paul, & Volkmar, 2014]. In fact, while structural language is known to change widely among children with ASD, difficulties in PL have been considered a hallmark of this clinical profile [Andrés-Roqueta & Katsos, 2017; Volden & Phillips, 2010]. This is true even in the absence of any intellectual disability [Paul, Landa, & Simmons, 2014], or other impairments in domains such as syntax, semantics, and phonology [Loukusa & Moilanen, 2009; Young, Diehl, Morris, Hyman, & Bennetto, 2005]. Various conversational deficits have been described in individuals with ASD, such as a weaker ability to take turns, difficulty

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in making appropriate judgments about how much to say in a conversation, impaired prosody, difficulty understanding implicit or ambiguous meanings, managing topic shifts, but also problems with taking another's perspective, and with structuring narratives [Kuijper, Hartman, Bogaerds-Hazenberg, & Hendriks, 2017; Paul et al., 2014; Volden & Phillips, 2010]. In addition, impairments with understanding different aspects of nonliteral language have been reported [Whyte & Nelson, 2015], such as metaphors and figurative language [Dennis, Lazenby, & Lockyer, 2001; Happé, 1993; Nikolaenko, 2004; Norbury, 2005], drawing inferences and comprehending irony, metonymy and indirect requests [MacKay & Shaw, 2004; Ozonoff & Miller, 1996], and disambiguating meanings of polysemous words automatically in context [Jolliffe & Baron-Cohen, 1999; Brock, Norbury, Einav, & Nation, 2008]. These impairments strongly affect the social relations of children with ASD and tend to persist in adolescence and adulthood [Berenguer, Miranda, Colomer, Baixauli, & Roselló, 2018]. Confirmation of the significant impairments in PL in adolescents with ASD comes, for example, from the work of Freitag, Kleser, and von Gontardf [2006], which investigated language abilities in adolescents with ASD without language delay. Results showed differences between participants with ASD and controls in PL and in some spontaneous speech measures (i.e. communicative behavior, articulation and prosody, semantic, and syntactic structure).

Given the complex nature of PL, some published studies suggest the importance of investigating the role of different factors underlying this domain [Atkinson, 1979; Lapadat, 1991; Martin & McDonald, 2003]. As Andrés-Roqueta and Katsos (2017) suggested, impairments in PL could be attributed to specific features of ASD, like difficulties in integrating information from the context [Weak Central Coherence; Happé & Frith, 2006], deficits in Theory-of-Mind [ToM; Baron-Cohen, Leslie, & Frith, 1985], impairments in executive functions [EFs; Hill, 2004] or lack of social motivation [Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012]. Notably, both social and cognitive skills seem to underlie PL [Lapadat, 1991]. In particular, two primary proposals are reported in the literature about the source of these PL impairments in ASD. The first view arises from the ToM approach, which suggests that ToM might contribute to explain PL deficits in children with ASD, being involved in inferring intentions and mental states of other people. The second view concerns EFs theory, suggesting that the PL difficulties of children with ASD could be due to poor inhibition or cognitive flexibility [Andrés-Roqueta & Katsos, 2017; Eigsti, de Marchena, Schuh, & Kelley, 2011; Martin & McDonald, 2003].

ToM can be defined as the ability to attribute mental states to oneself or others and to use these attributions to explain and predict others' behavior [Dennett, 1980; Frank, Baron-Cohen, & Ganzel, 2015]. ToM is fundamental to humans' social interaction [Frith & Frith, 2003; Milligan et al., 2007]. An interesting paper by Astington and Jenkins [1999] analyzed the possible link between ToM and language skills by reviewing the different types of relationships that could exist between these two skills (i.e. ToM depends on language, language depends on ToM or ToM and language both depend on some other factors, such as EFs). Some authors argued that the development of structural features of language (i.e. syntax) promotes ToM development [Astington & Jenkins, 1999]. Looking at the relationship between PL and ToM, previous studies considered ToM a precursor of social communication skills [Happé, 1993; Winner, Brownell, Happé, Blum, & Pincus, 1998]. Others suggested instead that engaging in social interaction and communicating with other individuals enables the development of an efficient ToM [Peterson & Siegal, 2000; Nelson, 1996]. Filippova and Astington [2008] analyzed the relationships between receptive vocabulary, ToM and a specific aspect of PL (i.e. the children's interpretation of irony), demonstrating that ToM and language made important contributions to children's interpretation of irony even after controlling for the impact of age, memory, and attunement to expressive prosody. Thus, a huge amount of studies suggested a close link between PL and ToM [Lorusso, 2009; Martin & McDonald, 2003; Thoma & Daum, 2006].

Basic social perception skills and PL are also extremely important in the clinical profile of individuals with ASD. Some studies found an association between an impaired ToM and deficits in PL in individuals with ASD [Losh & Capps, 2003; Losh, Martin, Klusek, Hogan-Brown, & Sideris, 2012; Tager-Flusberg, 2000]. Correlational evidence between specific aspects of PL, such as irony understanding, and ToM have been found in children with ASD and TD [Happé, 1993; Filippova & Astington, 2008]. In addition, a good level of ToM is considered necessary for the correct interpretation of some communicative exchanges and for understanding metaphors [Happé, 1993]. Also the correct use of referring expressions during narratives requires ToM abilities and the difficulties of children with ASD in structuring narratives would provide evidence for the ToM deficit account [Marinis, Terzi, Kotsopoulou, & Francis, 2013; Siller, Swanson, Serlin, & Teachworth, 2014]. Martin and McDonald [2003] suggested that deficits in PL could contribute to an impaired ToM, and individuals with a limited experience of social communication may consequently fail to understand that a verbal message represents an individual's subjective mental state. Other authors found no such strong relationship between PL and ToM in ASD, however. For example, Whyte and Nelson [2015] produced evidence to support the hypothesis of ToM having a stronger role in the development of PL in children with typical development (TD) than in children with ASD. The results of their study highlighted that ToM was only related to a general pragmatic language measure for the TD group and not for the children with ASD. While, looking at a more specific measure of PL as nonliteral language comprehension skills, the relationship with ToM emerged for both ASD and TD. Schuh, Eigsti, and Mirman [2016] reported that though ToM abilities were found to contribute to discourse performance, it is not possible to conclude that ToM limitations lead directly to pragmatics difficulties.

EFs comprise a system of different, but related cognitive processes involved in planning, problem solving, and goal-directed activities [Miyake et al., 2000]. These higher-order control mechanisms regulate the dynamics of human cognition and action [Stuss & Alexander, 2000]. It is generally agreed that there are three main EFs: inhibition, updating, and cognitive flexibility, or set shifting [Diamond, 2013; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000; Miyake & Friedman, 2012].

Inhibitory control concerns our ability to control our attention, behavior, thoughts, and/or emotions in order to prevent familiar, over-learned or irrelevant information from hampering the achievement of a goal. It ensures a coherent and organized behavior based on relevant information [e.g. Dagenbach & Carr, 1994; Diamond, 2013; Friedman & Miyake, 2004]. Updating abilities enable us to constantly monitor the contents of our working memory (WM), so that we can rapidly make additions and deletions to keep them up to date [Miyake & Friedman, 2012]. This system is supported by two separate sets of domain-specific resources for handling verbal and visuospatial information. These resources are crucial in everyday life: we use them to keep in mind and manipulate information arriving from outside, and thus produce consistent and appropriate responses to contextual demands [Giofrè, Mammarella, & Cornoldi, 2013; Shah & Miyake, 1996]. Cognitive flexibility builds on inhibitory control and WM [Davidson, Amso, Anderson, & Diamond, 2006; Garon, Bryson, & Smith, 2008], giving us the flexibility we need to change our interpersonal perspective, adjust our priorities, admit our mistakes, and promptly take advantage of unexpected opportunities [Diamond, 2013].

Some researchers have claimed that deficits in EFs might cause impairments in PL [e.g. Zelazo et al., 2003]. Associations between EFs and PL found in children with ASD pointed to weaknesses in the former leading to poorer pragmatic skills in this clinical group [Filipe, Veloso, Frota, & Vicente, 2019]. Children with deficient EFs might struggle to organize and monitor their thoughts efficiently, this would frequently result in misunderstandings, and the reciprocity needed for satisfactory communication would often suffer as a consequence [Clark, Prior, & Kinsella, 2002]. In particular, failures of children with ASD at pragmatic tasks may be due to their difficulties in simultaneously consider and respond to multiple sources of information or to inhibit inappropriate, potent, or salient responses [Eigsti et al., 2011]. PL seems also to rely, to some extent at least, on cognitive planning and task execution, both of which are aspects of EFs that demand inhibition, updating, and cognitive flexibility [McDonald, 1993]. It is also worth noting that other studies involving groups of children with ASD did not find significant relationships between the PL domain and measures of EFs, when correlational analyses were performed for the group with ASD [i.e. Berenguer et al., 2018].

Different lines of research revealed a close link between PL and EFs or ToM [McDonald, 1993; Martin & McDonald, 2003; Thoma & Daum, 2006], but only a few studies to our knowledge explored the relationship between these three domains in children with ASD, and they generally focused only on specific aspects of PL. This latter can be considered to be strictly related with the cognitive, social and linguistic development [Adams, 2002], and several studies have shown that ToM and EFs are fundamental to our understanding of social and cognitive development [Kimhi, Shoam-Kugelmas, Ben-Artzi, Ben-Moshe, & Bauminger-Zviely, 2014]. For example, narrative abilities have been found related to ToM and WM, suggesting the involvement of both these abilities in PL, and its impairments [Kuijper et al., 2017]. These findings highlight the complex relationships between PL, ToM, and EFs and point to the importance of studying PL skills in children with ASD, and comparing them with children showing a TD. However, research on PL, and particularly on how this domain correlates with other social and cognitive abilities, is still insufficient and contradictory [Adams, 2002].

As previously mentioned, PL is a complex and multifaceted construct. In the present study, we focused on two specific aspects, such as the comprehension of nonliteral language, and the ability to make inferences. Hereafter, we will refer to these two aspects using the term PL. Specifically, with the present study, we aimed (a) to confirm impaired PL in participants with ASD with no intellectual disability by comparison with children with TD, using tasks devised specifically for this study; (b) to ascertain the relation among PL, ToM and EF and how much of the variance in PL is accounted for those factors, over and above the effect of group (ASD or TD), demographic variables (age and gender) and general cognitive abilities (IQ); and (c) to examine the mediating role of social and cognitive factors (i.e. ToM, and EFs respectively) in the clinical group's PL.

We expected to find impairments in the ASD group compared with the TD group for most of the tasks regarding the three domains investigated [Paul et al., 2014; Martin & McDonald, 2004; Kissine, 2012]. Given the close link between PL and EFs or ToM [Kuijper et al., 2017; McDonald, 1993; Martin & McDonald, 2003; Thoma & Daum, 2006], we might expect to find a significant effect of both ToM and EFs in sustaining participants' PL performance. We also aimed to highlight a potential mediating effect of ToM and EFs on their PL.

Method

Participants

We collected data for 143 children and adolescents, aged between 8 and 18 years, 73 with ASD (males = 65; M_{age} = 160.40, SD = 44.18), and 70 controls (males = 58; M_{age} = 166.37, SD = 41.69). The two groups did not differ statistically by age in months, F (1, 141) = 0.69, p = 0.408, gender, χ^2 (1, N = 143) = 1.34, P = 0.286, Cramer-V = 0.089) or receptive language skills F (1, 141) = 0.23, P = 0.631. They were also comparable in terms of IQ, F (1, 141) = 1.90, P = 0.170, as measured with the Italian adaptation of the Wechsler Intelligence Scale for Children-IV [WISC-IV; Wechsler, 2003], or the Wechsler Adult Intelligence Scale-IV [WAIS-IV; Wechsler, 2008], depending on their chronological age (for participants aged 8–15 years and 11 months, WISC-IV was administered, while for participants aged from 16 years, WAIS-IV was administered).

The control group consisted of healthy children of normal intelligence with no history of psychiatric, neurological or neurodevelopmental disorders. All participants in the ASD group had been diagnosed at centers specializing in ASD, according to the DSM-IV-TR [American Psychiatric Association (APA), 2000] or ICD-10 [World Health Organization (WHO), 1992] criteria. Diagnoses of ASD were also confirmed by administering the Autism Diagnostic Interview—Revised (ADI-R; Rutter, Couteur, & Lord, 2005) and by an interview with an expert practitioner. Participants with ASD were selected if they: had a standard score of 80 or more for full-scale IQ; scored within normal range (80 or above) on a test measuring receptive language (Test for Reception of Grammar – Second edition [TROG-2]) [Bishop, 2009] and were taking no medication. Children with other known genetic conditions, neurological diseases, comorbid psychopathologies or physical disabilities were excluded.

Participants were recruited through local contacts with specialist centers for ASD, or with schools. All participants were native Italian speakers of white ethnicity. Ethical approval was obtained from the research ethics committee at the University of Padova. All participants assented to their participation in the study, and their parents gave their written informed consent. The participants' characteristics are summarized in Table 1.

Materials

All the instruments described below were administered in Italian.

Pragmatic language

Metaphors. This is a paper-and-pencil task devised *ad hoc* for this study, based on the Metaphors subtest of the APL Medea battery [Lorusso, 2009]. The Metaphors task assesses participants' ability to go beyond the literal

TABLE 1. Characteristics of the Groups: Descriptive Statistics and Statistical Analyses for Individuals With Autism Spectrum Disorder (ASD) and Those With Typical Development (TD)

Measures	ASD (n = 73)	TD (n = 70)	F (1, 141)	P	Cohen's d
Gender (M:F)	65:8	58:12			
Age (months)					
Mean (*SD*)	160.40 (44.18)	166.37 (41.69)	0.69	0.408	0.14
Range	96–227	96–227			
IQ					
Mean (*SD*)	106.47 (15.74)	109.91 (14.10)	1.90	0.170	0.23
Range	82–135	88–138			
TROG-2					
Mean (*SD*)	100.70 (12.26)	101.67 (11.88)	0.23	0.631	0.08
Range	80–127	80–127			
ADI-R:A (Reciprocal social interaction)					
Mean (*SD*)	16.90 (4.70)	3.81 (2.74)	409.8	<0.001	3.38
Range	11–26	0–10			
ADI-R:B (Language/communication)					
Mean (*SD*)	12.20 (3.10)	2.76 (1.98)	466.2	<0.001	3.61
Range	9–22	0–7			
ADI-R:C (Repetitive behaviors/interests)					
Mean (*SD*)	6.20 (2.12)	0.60 (0.84)	424.8	<0.001	3.45
Range	4–12	0–3			

SD: standard deviation; IQ: intelligence quotient on the Wechsler Intelligence Scale for Children–IV [Wechsler, 2003] or Wechsler Adult Intelligence Scale–IV [Wechsler, 2008]; TROG-2: Test for Reception of Grammar – Second edition [Bishop, 2009]; ADI-R: Autism Diagnostic Interview–Revised [Rutter et al., 2005].

meaning of spoken sentences and to explain their underlying meaning. The task consists of two different subtests: verbal and pictorial metaphors. In the first, verbal subtest, participants are presented with 10 metaphorical sentences (e.g. Carlo is a fox) and asked to explain their figurative meaning. In the second, pictorial subtest, participants need to indicate which of four pictures represents the meaning of a metaphorical sentence (e.g. "Luca is a bookworm", in which case the correct answer is a picture showing a character reading lots of books, while the other three pictures show a worm reading a book [literal distractor], a group of children in a public library [semantic distractor], and a boy looking at a worm on a bookcase [partial distractor]). This task consists of 10 items in each subtest. Participants are awarded two points for a correct answer, or one for a partially correct answer, in the verbal subtest (maximum raw score = 20 points), and one point for each correct answer in the pictorial subtest (maximum raw score = 10 points). Cronbach's alpha = 0.83 for the verbal subtest, and = 0.78 for the pictorial subtest.

Inferences. This is a paper-and-pencil task devised *ad hoc* for this study, which assesses the ability to infer information not explicitly stated. This task consists of two different subtests: verbal and pictorial inferences, each concerning both social and nonsocial conditions. Participants are asked to listen to short stories (verbal inferences) or to look at figures of some scenes (pictorial inferences), then answer questions regarding information that can be drawn from contextual cues or previous knowledge. Each condition of this task consists of 10 items. Participants are awarded two points for each correct answer, or one for a partially correct answer (maximum raw score = 20 points in each condition). Cronbach's alpha = 0.86.

Theory of Mind

Reading the Mind in the Eyes Test – Children's Version [Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001]: this is a static measure of ToM based on 28 photographs of the eye region of human faces. Participants are asked to look at the face and choose which of four words describing mental states best describes what the person in the photograph is thinking or feeling. Participants receive one point for each correct answer (maximum raw score = 28 points). The test–retest reliability was = 0.83.

Verbal ToM [Nepsy-II; Korkman, Kirk, & Kemp, 2007]: this is a measure of the ability to understand beliefs, emotions, and intentions, and to understand that other individuals have their own thoughts and feelings. In this task, participants listen to descriptions of scenarios or are shown pictures and are then asked to answer questions about another individual's point of view. The raw scores obtained by each participant (maximum raw score = 17 points) were compared with normative values, and z scores were computed. The test–retest reliability was = 0.77.

Executive Functions

Inhibition and Switching [Nepsy-II; Korkman et al., 2007]: for the present study, two subtests—inhibition and switching—were selected from the Inhibition task in the Nepsy-II battery. These timed tasks respectively assess the ability to inhibit automatic responses in favor of novel responses and the ability to switch between response types. In the Inhibition subtest, participants are asked to look at a series of black and white shapes or arrows, inhibit the natural response, and name the opposite of the correct response. In the switching subtest, participants are asked to switch between providing the correct and the opposite responses, depending on the color of the stimulus. Response times and error rates are recorded, and a combined score ($M = 10$, $SD = 3$) is computed for each subtest, which pools error rates and completion times. The test–retest reliability was = 0.82 for inhibition, and = 0.93 for switching.

Updating. Updating is a computerized task [E-Prime; Schneider, Eschman, & Zuccolotto, 2007] devised *ad hoc* for this study to examine the ability to constantly monitor and update information in memory. It consists of two subtests presenting verbal and visuospatial stimuli. The verbal updating subtest comprises eight lists of spoken words belonging to 12 categories (i.e. fruits, colors, food, animals, cities, months, sports, body parts, clothes, jobs, vegetables, means of transport). Lists of 6, 8, 10, or 12 words are used, and there are two trials for each list length. Participants are asked to listen to each list, and then recall the last term of each list that belongs to a given category presented on the screen. The number of words to recall ranges from 2 to 5, depending on the length of the list. In the visuospatial updating subtest, participants are shown a 4 × 4 blank matrix displayed on the computer screen. A total of eight sequences of various shapes (i.e. triangle, circle, star, square, rhombus, pentagon) are presented in the matrix. Sequences of 6, 8, 10, or 12 shapes are used, and there are two trials for each sequence length. Participants are asked to look at the sequence being presented and then recall the last position of certain shapes shown on the screen. The number of shapes to recall ranges from 2 to 5, depending on the length of the sequence. Before starting the experiment, participants are familiarized with each task in three practice trails. The proportion of words/shapes correctly recalled in each subtest is recorded. Cronbach's alpha = 0.78 for the verbal task and = 0.86 for the visuospatial task.

Statistical Approach

First, a series of univariate ANOVAs were performed to estimate differences between the groups in the measures of PL, ToM, and EFs. The number of variables involved in this study was relatively high (see Table 2 for descriptive statistics), so principal component analysis (PCa) was used to reduce the number of variables being considered. We ran a series of PCa, one for each factor in the study, that is, PL (including the measures of Metaphors and Inferences), ToM (including the Reading the Mind in the Eyes Test – Children's Version and the Verbal ToM test), and EFs (including the measures of Inhibition, Switching and Updating). These factors, obtained with the PCa, were then used in the subsequent analyses.

Second, in order to analyze the associations between severity of ASD symptoms (as measured by ADI-R A + B scores), PL, ToM and EFs in each group considered, Pearson correlation analyses were performed separately for each group.

Third, a series of linear regressions were conducted to investigate the contribution of EFs and ToM to PL, controlling for group, demographic variables (i.e. age and gender), and general cognitive abilities (i.e. IQ). The linear regressions consisted mainly of five steps, with group entered in the first model, demographic variables in the second, IQ in the third, EFs in the fourth, and ToM in the fifth and final model. By analyzing the differences in the variance that each model accounted for, the predictive role of each construct (group, demographic variables, IQ, EFs and ToM) can be assessed while disregarding the other constructs.

Finally, mediation models were constructed in an effort to identify and explain the mechanism or process underlying an observed relationship between PL and group, via the inclusion of a third hypothetical "mediator variable" (e.g. ToM and EFs). In statistics, a mediation model refers to a causal pathway through which effects are conducted from an independent variable through a mediator variable to a dependent variable. The mediator variable transmits part of the effect of the causally prior variable to a third variable affected by the mediator [Kline, 2016]. Thus, the mediator variable helps to clarify the nature of the relationship between the independent and dependent variables [MacKinnon, 2008]. Path analysis is a more advanced statistical technique, which allows to test more complex hypotheses, as compared to regression. In this case, the regression is indicating that differences in the outcome variable are explained for by a set of predictors, controlling for, or testing the effects above and beyond, every single variable included as a predictor. Path analysis, on the other hand, is trying to provide a different information, and in particular is trying to explain a complex pattern of relationship between indicators. In this particular case, path analysis allows to shed more light on the relationship between group and PL. We decided to use the option mentioned by Preacher and Hayes (2008), that is, to select relevant mediators from a series of univariate models [e.g. Boca, Sinha, Cross, Moore, & Sampson, 2014; Liu et al., 2013]. Although, several other approaches are possible, this method has several advantages, for example, it is easier to evaluate, and betas tend to be immediately understandable [van Kesteren & Oberski, 2019]. R software [R Core Team, 2019] was used to perform the statistical analyses, with the lavaan package [Rosseel, 2012], and bootstrap estimates were calculated with 10,000 replications. The model's goodness of fit was measured considering the R^2 of each endogenous variable, and the total coefficient of determination [TCD; Bollen, 1989; Jöreskog & Sörbom, 1996].

TABLE 2. Descriptive Statistics and Statistical Analyses by Group for the Measures of Pragmatic Language, Theory of Mind and Executive Functions, in Individuals With Autism Spectrum Disorder (ASD) and Those With Typical Development (TD)

	ASD		TD				
	M	SD	M	SD	$F(1, 141)$	P	Cohen's d
Pragmatic language							
Verbal metaphors	11.93	5.27	15	4.77	13.29	<0.001	−0.61
Pictorial metaphors	6.64	2.36	7.93	2.46	10.15	<0.001	−0.53
Social inferences—Verbal	17.19	2.75	18.59	1.43	14.27	<0.001	−0.63
Nonsocial inferences—Verbal	16.51	2.68	17.69	1.89	9.15	0.003	−0.51
Social inferences—Pictorial	17.05	2.28	18.14	1.83	9.84	0.003	−0.52
Nonsocial inferences—Pictorial	17.44	1.63	18.3	1.6	10.15	0.002	−0.53
Theory of mind							
Eyes test	18.41	4.1	19.77	3.44	4.6	0.034	−0.36
Verbal ToM	−0.84	1.89	0.27	0.77	20.7	<0.001	−0.76
Executive functions							
Inhibition	6.97	3.41	9.14	2.93	16.64	<0.001	−0.68
Switching	7.12	3.74	8.67	2.32	8.77	0.004	−0.50
Verbal updating	0.65	0.16	0.74	0.15	10.42	0.002	−0.54
Visuospatial updating	0.58	0.23	0.71	0.18	13.73	<0.001	−0.62

Results

Preliminary Analyses

Descriptive statistics and statistical comparisons between the two groups (ASD and TD controls), are presented in Table 2, which shows that the two groups differed statistically in all measures considered.

Figure 1 shows the differences between groups in accuracy for each of the constructs obtained from the PCa: PL, ToM, and EFs.

Correlation Analyses

Results of correlation analyses between severity of ASD symptoms (as measured by ADI-R A + B scores), PL, ToM, and EFs by group are summarized in Table 3. As represented in the table, the severity of ASD symptoms do not correlate with PL, ToM, and EFs neither in ASD nor in TD participants. Significant strong correlations emerged between PL and ToM for both ASD ($r = 0.546$, $P < 0.001$) and TD ($r = 0.675$, $P < 0.001$) participants. In addition, significant medium correlations between PL and EFs measures emerged only for participants with TD ($r = 0.361$, $P = 0.002$). No significant correlations between ToM and EFs measures emerged neither in ASD nor in TD participants.

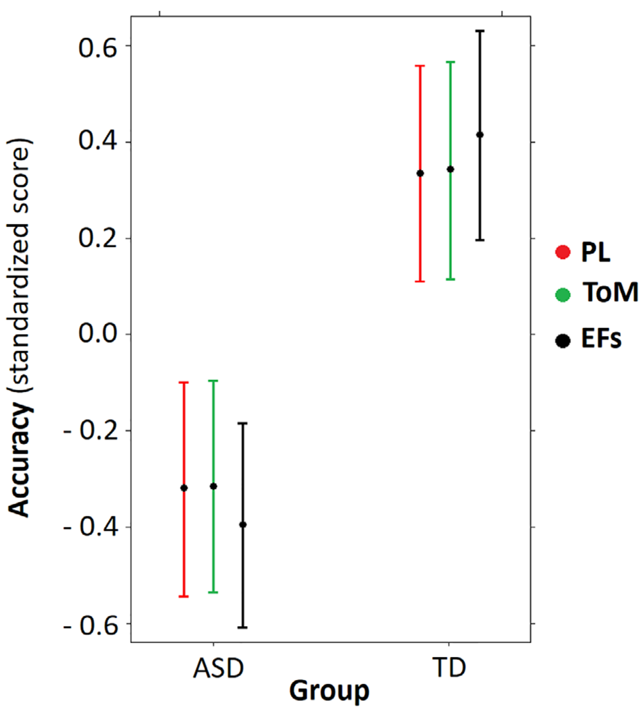

FIGURE 1. Predicted accuracy by group for each of the constructs obtained from the principal component analysis (PCa), pragmatic language (PL), theory of mind (ToM), and executive functions (EFs). Accuracy is expressed in standardized scores (Mean = 0 and Standard Deviation = 1). Error bars represent 95% confidence intervals. TD = typically developing; ASD = autism spectrum disorder.

TABLE 3. Pearson Correlation Coefficients between ADI-R A + B Scores, PL, ToM and EFs Measures in ASD (Lower Diagonal) and TD (Upper Diagonal) Groups

	ADI-R A + B	PL	ToM	EFs
ADI-R A + B	1	−0.052	−0.123	0.030
PL	−0.090	1	0.675**	0.361**
ToM	−0.138	0.546**	1	0.146
EFs	−0.012	0.046	0.124	1

Note. **$P < 0.01$; *$P < 0.05$.

Regression Analyses

A series of linear regression models were run. Group (ASD and TD), demographic variables (age and gender) and general cognitive abilities (IQ) were entered in the model in a first step, while EFs and ToM were included in subsequent steps to quantify the portion of the variance in PL accounted for by EFs and ToM, over and above the other variables. Taken together, our variables accounted for 54% of the variance in PL, $F(6, 136) = 28.74$, $P < 0.001$, with Group, $\Delta R^2 = 0.10$, $F(1, 141) = 16.91$, $P < 0.001$, demographic variables, $\Delta R^2 = 0.24$, $F(2, 139) = 27.45$, $P < 0.001$, and general cognitive abilities, $\Delta R^2 = 0.03$, $F(1, 138) = 5.96$, $P = 0.02$, accounted for a significant proportion of this variance. After controlling for the effects of these variables, EFs did not account for a significant proportion of the variance, $\Delta R^2 = 0.002$, $F(1, 137) = 0.44$, $P = 0.51$, while ToM was a significant predictor of PL, $\Delta R^2 = 0.17$, $F(1, 136) = 52.65$, $P < 0.001$. In the final model, which included all the variables, only the effects of age and ToM remained statistically significant, after controlling for the effects of all the other variables (see Table 4), suggesting that PL abilities were higher in participants who were older ($P < 0.001$), and in those with stronger ToM abilities ($P < 0.001$). Interestingly, when the effect of all variables was taken into account, the effect of Group was no longer statistically significant ($P = 0.06$), and it was small in terms of effect size.

Univariate Mediation Analysis

The results of our regression analyses showed that ToM was a significant predictor of PL, while EFs were not. Although the path from EFs to PL was not statistically significant, it may be that EFs play a part in the relationship between group and PL. In other words, the statistical removal of a mediational or confounding effect could increase the magnitude of the relationship between the independent and dependent variable [MacKinnon, Krull, & Lockwood, 2000]. We therefore tested the hypothesis that EFs and ToM might mediate the relationship between

TABLE 4. Summary of Regression Analysis on Pragmatic Language

	B	*SE*	*β*	*t*	*P*	R^2
Model 1						0.10
Group	0.65	0.16	0.33	4.11	**<0.001**	
Model 2						0.34
Group	0.57	0.14	0.28	4.17	**<0.001**	
Age	0.47	0.07	0.47	6.76	**<0.001**	
Gender	0.33	0.20	0.11	1.64	0.10	
Model 3						0.37
Group	0.53	0.13	0.27	3.98	**<0.001**	
Age	0.44	0.07	0.44	6.39	**<0.001**	
Gender	0.29	0.20	0.10	1.50	0.14	
IQ	0.17	0.07	0.17	2.44	**0.02**	
Model 4						0.37
Group	0.49	0.15	0.25	3.37	**<0.001**	
Age	0.44	0.07	0.44	6.35	**<0.001**	
Gender	0.30	0.20	0.11	1.54	0.13	
IQ	0.15	0.07	0.15	1.96	**0.05**	
EFs	0.05	0.08	0.05	0.67	0.51	
Model 5						0.54
Group	0.24	0.13	0.12	1.86	0.06	
Age	0.39	0.06	0.39	6.57	**<0.001**	
Gender	0.02	0.17	0.008	0.13	0.89	
IQ	0.04	0.06	0.04	0.62	0.54	
EFs	0.04	0.07	0.04	0.58	0.56	
ToM	0.47	0.06	0.47	7.26	**<0.001**	

Note. Bold values denote statistical significance at the $P < 0.05$ level. EFs: executive functions; IQ: intelligence quotient; ToM: theory of mind.

PL and group (ASD or TD). We found that ToM had a mediating effect on PL, the indirect effect (ab) proving statistically significant, $\beta = -0.19$, $P = 0.001$. For EFs, on the other hand, the indirect effect (ab) was not statistically significant, $\beta = -0.035$, $P = 0.297$ (see Fig. 2). Overall, this model explained 40.2% of the variance with a TCD = 0.25. In terms of effect size, this corresponds to a correlation $r = 0.50$, which is large according to Cohen's (1988) criteria. These findings corroborate the results of the simple regressions and seem to identify ToM, but not EFs, as an important mediator between group and PL. When considered in the final model, the effect of group was not statistically significant, that is the relation between group and PL was not significant, $\beta = -0.10$, $P = 0.153$ (see Fig. 2). In fact, the effects depend on the complex system of the equations in which they are included. A possible explanation for this is that the impaired PL in the ASD group is at least partly mediated by ToM, whereas the mediation of EFs (described in the literature) is not statistically significant and tends to be small in terms of effect size. In other words, this analysis indicates that differences between the two groups in PL are explained through the mediation of ToM and EFs, and that once these variables are both entered into the same equation the path from group to PL is no longer statistically significant. Looking at these two mediators, however, it seems that ToM has an indirect effect on PL, while the impact of EFs, is somewhat smaller. This finding seem to indicate that ToM is mediating the relationship between groups and PL, while EFs is somewhat relevant for explaining group differences, but once the effect of group is accounted for by its indirect effect is rather small and not statistically significant.

Discussion

The present study aimed to contribute to our understanding of PL in children with ASD and no intellectual disability. In particular, two specific aspects of PL were investigated, such as the comprehension of nonliteral language, and the ability to make inferences. We focused mainly on analyzing the underlying role of two fundamental social and cognitive abilities, ToM and EFs, in our participants' PL performance. Comparing a group of children and adolescents (hereafter defined as children) with ASD and a group with TD, we expected to clarify how this complex and underexplored domain works, taking into account the possible mediating role of our participants' ToM and EFs.

Our first aim—to compare the PL abilities of children with ASD and children with TD, using tasks created *ad hoc* for this study—focused on producing empirical evidence to confirm that PL were impaired in our clinical group. As expected, our results revealed deficits in the group with ASD, whose performance was less accurate than the TD group's on all the measures of PL. This result is in line with previous studies highlighting PL impairments in ASD [Colle et al., 2008; Kim et al., 2014; Kuijper et al., 2017; Norbury & Bishop, 2002; Paul et al., 2014; Simmons et al., 2014]. While these difficulties in PL have repeatedly been documented in individuals with ASD

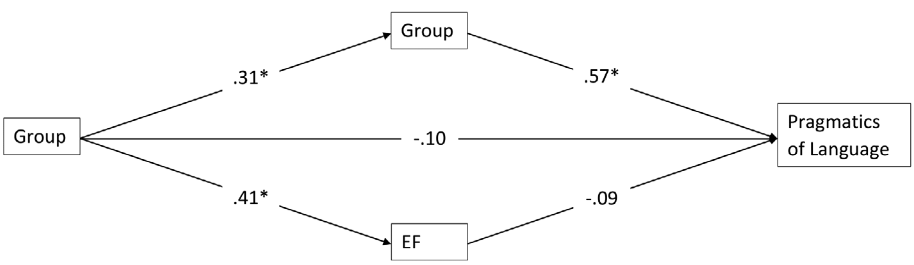

FIGURE 2. Path model with standardized coefficients. *$P < 0.05$.

(as mentioned above), the factors behind these impairments remain less clear [Martin & McDonald, 2003]. Some studies have sought to explore the complex nature of PL by investigating underlying skills closely related to this domain, that is, ToM and EFs, often with contradictory results [Filipe et al., 2019; Losh & Capps, 2003; Losh et al., 2012; Tager-Flusberg, 2000; Whyte & Nelson, 2015]. It is worth noting that only a handful of studies explored the relationship between all three of these domains in children with ASD [i.e. Kuijper et al., 2017].

The second aim of our study was thus to see the relationship among PL, ToM and EF and whether ToM and EFs could predict the two groups' performance in our PL measures. To do so, we examined the relative contribution of ToM and EFs to our participants' PL abilities, controlling for the effect of group, demographic variables (age and gender) and general cognitive abilities (IQ). The results of our final regression model, taking the effect of all variables into account, showed that chronological age and ToM abilities were significant predictors of our groups' PL. Concerning the effect of age, our results showed that PL abilities were higher in older participants, confirming that PL improved with development across childhood and adolescence, in both ASD and TD. These results are consistent with previous studies on the effect of age on measures of PL in groups of children with TD [Nippold, 2000; Ryder & Leinonen, 2014], and ASD [Loukusa et al., 2007; Whyte & Nelson, 2015], which likewise showed that PL abilities improved with age and experience. We also found that ToM had an effect on PL, that is, participants with higher PL abilities also had stronger ToM abilities. This finding is also consistent with previous reports of significant associations between competence in ToM and the PL index of participants with ASD or TD [Berenguer et al., 2018; Kuijper et al., 2017; Losh et al., 2012]. In addition, consistently with the study by Whyte and Nelson [2015], our results provide further evidence to support the conviction that ToM abilities contribute to the development of PL abilities in both ASD and TD. One possible explanation of these results is that as children get older their ToM also improves in parallel and both age and ToM are related to PL abilities.

Our results also showed that EFs were not a statistically significant predictor of our participants' PL abilities. The previous literature contains conflicting findings on the relationship between EFs and PL in ASD. Some authors found evidence of a link between deficits in EFs and PL impairments [Filipe et al., 2019], while other researchers did not [Berenguer et al., 2018]. Our results are consistent with the findings of Berenguer et al. [2018], as the variance in PL explained by EFs was minimal ($\beta = 0.04$), and their effect was not statistically significant. However, it is worth noting that our correlational analyses suggested that PL was related to EF only in the TD group, and that the severity of ASD symptoms did not correlate with PL, ToM and EFs neither in ASD nor in TD participants. In line with the results of our regression analyses, we concluded that ToM abilities were a significant predictor of PL, while EFs were not.

To further explore the relationship between group (ASD and TD) and PL, we analyzed whether the group variable indirectly influenced PL performance via the inclusion of ToM and EFs as mediators. Consistently with the results of the regression analysis, we found a significant indirect effect of group on PL via ToM. This result confirmed once again the important association between ToM difficulties and PL impairments in individuals with ASD [Losh & Capps, 2003; Losh et al., 2012; Tager-Flusberg, 2000] and highlights the crucial contribution of ToM abilities to the effective use of PL both in TD children and children with ASD [Hughes & Leekam, 2004; Whyte & Nelson, 2015].

On the other hand, the mediation of EFs was not statistically significant. This result is in contrast with what emerged from the study by Filipe et al. [2019], who found a significant indirect effect of group on PL via EFs. The authors concluded that, in individuals with ASD, impairments in EFs are associated with weaknesses in PL. Various factors may explain this inconsistency, from the characteristics of the samples considered to the measures used to assess EFs. It is worth noting that the sample in the study conducted by Filipe et al. [2019] consisted of only 15 participants from 5 to 9 years old in each group (ASD and TD), while our study involved a much larger number of participants ($N = 143$) and a wider age range. Another aspect to consider concerns the different measures of EFs used, which were parents' ratings in the study by Filipe et al. [2019], as opposed to direct assessments in the present study. Such differences could be responsible for the different results obtained, and future studies might clarify these inconsistencies.

To sum up, our results confirmed that impairments in PL are a crucial characteristic of the ASD profile [Kim et al., 2014; Loukusa & Moilanen, 2009; Simmons et al., 2014]. Deficits in ToM and EFs emerged in our group with ASD too, when compared with TD peers, consistently with previous reports [Frith, 2001; Hill, 2004; Rajendran & Mitchell, 2007; Senju, Southgate, White, & Frith, 2009]. Although children with ASD were more impaired than those with TD in both ToM and EFs, when the effect of ToM and EFs on participants' PL was considered, only ToM contributed significantly to the relationship between group and PL. This finding is in line with the suggestion that the understanding of mental states is related to the development of PL [Eisenmajer & Prior, 1991] and social skills [Astington & Jenkins, 1995; Frith, 1994] and with the results demonstrating that ToM abilities made important contributions to children's PL [Filippova & Astington, 2008]. In fact, ToM impairments might prevent children with ASD from inferring intentions and mental states of other people, providing a critical constraint on PL [Andrés-Roqueta & Katsos, 2017; Eigsti et al., 2011; Martin & McDonald, 2003]. Consequently, a good level of ToM is considered necessary for the correct interpretation of some communicative exchanges, for understanding metaphors [Happé, 1993] and seemed to be related to nonliteral language comprehension skills, in both ASD and TD [Whyte & Nelson, 2015].

Some clinical implications could be drawn from this study. Our findings underscore the importance of considering and investigating ToM abilities in individuals with ASD to shed more light on the PL profile of this clinical group. A better understanding of the predictors of impaired PL in children and adolescents with ASD can help us devise interventions tailored to the specific weaknesses of a given individual's clinical profile. The strong contribution of ToM to PL that emerged from our results points to the potential value of interventions not focused exclusively on PL, but also involving ToM abilities, in order to reach better outcomes. Previous studies showed that children with autism can be trained to show better PL abilities (i.e. maintaining the conversation topic, and making conversational utterances that are appropriate to the context) and that they could possibly learn ToM skills through such training [Chin & Bernard-Opitz, 2000]. In addition, the additive effect of a ToM and social skills program has been reported in ASD [Feng, Lo, Tsai, & Cartledge, 2008], showing after the training greatly improved ToM skills and positive social interactions. However, results of other studies revealed that ToM trainings, does not necessarily lead to improvement in some PL aspects or general social interaction [Hadwin, Baron-Cohen, Howlin, & Hill, 1997; Paul, 2003], suggesting that significant improvement in communication, mental state term usage, and mental state understanding may be achieved only after longer term teaching methods [Hadwin et al., 1997]. Thus, further research should be carried out on this topic in order to better explore these training effects.

Our findings shed more light on the complex relationships between PL, ToM, and EFs and suggest the importance of studying these skills in children with ASD, as compared with children with TD. Further work is needed to confirm and extend our results and to overcome some limitations of the present study. The inconsistencies in the literature suggest the importance of developing valid and standardized tools of PL and ToM, to improve our understanding and to better dissociate these domains; further studies should take into account this challenging issue. Interestingly, our results from the regression analyses have highlighted the significant contribution of age on PL; however, our experimental design did not allow to test for the effect of age in the mediation model because the system of the equation that we used was already very complex. Therefore, including one more variable might have created some statistical problems. Future studies should try to address this issue analyzing in depth the effect of age as mediator between group and PL. Future research should also include a larger proportion of female participants so as to explore possible gender differences in the PL profile of children with ASD. Another issue to investigate is whether the domains of ToM and EFs are associated differently with PL in males and females with this clinical diagnosis. It would also be interesting to compare the profiles of participants who have ASD with those of individuals who have other neurodevelopmental disorders associated with PL difficulties (e.g. ADHD), also assessing their respective ToM abilities and EFs.

Despite its limitations, the practical relevance of our results needs to be considered. As mentioned above, nonliteral language comprehension has a fundamental role in our communicative exchanges. Thus to interact successfully with others, we need to grasp information that is not explicitly stated, and to interpret nonliteral meanings. Impairments in these abilities could lead to failures in social interaction and cause consequent embarrassment in the speakers. For this reason, a correct assessment of nonliteral comprehension abilities and the promotion of subsequent training programs aimed at strengthening these areas of weakness, could make an essential contribution to improve conversational skills of children with ASD in daily life. Concluding, this study provides a comprehensive analysis of how ToM and EFs contribute to PL, assessed using objective measures. A large sample of children and adolescents with ASD was tested, and our results confirm the importance of considering the mediating role of ToM abilities on PL, while there was no evidence of EFs mediating the PL of children and adolescents with ASD or TD.

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