

Assessment of pragmatic skills in adults with ADHD¹

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ABSTRACT

Although Attention Deficit Hyperactivity Disorder (ADHD) is among the most common diagnoses in childhood, a formal diagnosis, frequently, is delayed until adulthood. As a result, the individuals who are not diagnosed in childhood miss out on the early treatment and may experience considerable social and pragmatic challenges, culminating in factors that impact their daily living, educational achievements and professional performance. Children and adolescents who do not receive an ADHD treatment carry their symptoms into adulthood, that typically result in functional and pragmatic difficulties. However, assessing pragmatic deficits in adults with ADHD presents challenges, stemming from various factors such as educational backgrounds, under-resourced family environments, compensatory mechanisms in individuals with high intelligence and the presence of other comorbid conditions. Consequently, overlooking pragmatic and functional difficulties can lead to significant social difficulties, which in turn may negatively impact their daily living, educational achievements and career progression. This study proposes a comprehensive and cost-effective approach to evaluating pragmatic skills in adults with ADHD, by adapting a systematic and standardized method, for the assessment of the pragmatic abilities, originally developed for neurotypical individuals by Acara and Bambini (2016). The results show the importance of incorporating this assessment tool into the diagnostic procedures for ADHD that can be further applied in the intervention programs. This assessment tool provides a valid onset criterion for advancing effective intervention programs that are focused on the pragmatic skills. Thus, this evaluation tool, first, can pinpoint pragmatic deficits within the ADHD community, and, second, can foster the development of the targeted intervention programs concentrated on enhancing pragmatic skills in the individuals with ADHD.

... what gets measured is what gets valued

(Lippman et al., 2014)

1. Introduction

ADHD (Attention Deficit/Hyperactivity Disorder) is a psychiatric disorder, which is associated with considerable societal and personal burden, described for the first time by Still (1902), however, as a clinical diagnosis, it appeared only in the 1930 s (Katzman et al., 2017; Lange et al., 2010). In fact, ADHD is one of the most common neurodevelopmental disorders in children (Wolraich et al., 2019) with reported prevalence of 5%–8% (Faraone et al., 2003; Gnanavel et al., 2019), though a considerable proportion of individuals are diagnosed

with ADHD only in the adulthood that may result from different factors, like the minimal demands required of them because of their environmental structure (Adler et al., 2015) with the worldwide prevalence in adulthood about 2.5% (Katzman et al., 2017; Simon et al., 2009). Indeed, the diagnosis of the disorder in the adulthood faces different obstacles (Faraone et al., 2004), that can be a result of numerous factors, e.g., educational or under-resourced familial environment, high intelligence compensating for stress-inducing difficulties (Fleischmann & Fleischmann, 2012).

Moreover, 80% of adults with ADHD have at least one coexisting psychiatric disorder (Katzman et al., 2017; Mostert et al., 2015; Sobanski et al., 2007; Torgersen et al., 2006). Among the most common comorbidities that co-occur in adults with ADHD are psychiatric disorders, like Bipolar Disorder (BD), Anxiety Disorders (AD), Major Depression Disorder (MDD), Substance Use Disorder (SUD) (such as, alcohol/nicotine,

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cannabis/cocaine addiction), Personality Disorders (PD) (for example, borderline, paranoid, obsessive-compulsive, narcissistic, passive-aggressive, avoidant). These comorbidities affect not only the diagnosis, but also a further treatment of ADHD. In addition to the significant prevalence of ADHD for comorbid psychiatric diagnoses, ADHD is also found to be the one of the most common comorbid disorders in individuals with Autism Spectrum Disorder (ASD) (Ileto, 2016; Simon-off, et al., 2008) due to the underlying neuropsychological deficits shared by ASD and ADHD (Mayes et al., 2012).

The criteria for ADHD, according to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V, American Psychiatric Association, 2013) refer to pragmatic dysfunction that includes: talking excessively, blurting out answers to questions before they are completed and interrupting others. Moreover, a meta-analysis of 30 empirical studies on pragmatic language in children with ADHD revealed: the difficulties producing coherent, fluent and organized speech for specific purposes; excessive talking, particularly in the situations when they are required to listen; difficulties in adopting an appropriate speaker and listener roles with tendency in dominating and not responding adequately to verbal cues; and difficulties with higher-level comprehension especially for story elements and inferences (Green et al., 2014). However, before the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (2013) was published, the ADHD diagnosis was excluded in cases the ASD was diagnosed (Stevens et al., 2016), thus, leaving behind children and adolescents undiagnosed with ADHD disorder. Following Faraone et al. (2004) the data on age at first ADHD diagnosis, along with the high prevalence of previously undiagnosed ADHD in adults, suggest the missed diagnostic opportunities in the past. Nowadays, they may comprise a prevalent rate of adults with ADHD who did not get an early treatment for ADHD disorder that might have a negative impact on their life from childhood till adulthood (Okumura et al., 2021).

These undiagnosed individuals in the adulthood may face different problems, like in financial management, parenting, marital life, occupational functioning and difficulties in cognition and education or healthy lifestyle (Barkley et al., 2008; Ernst et al., 2003; Fleischmann & Miller, 2013) and may suffer from the lack of self-confidence, stress or guilt feelings (Fleischmann & Fleischmann, 2012). This can be particularly true for females, who are a largely unrecognized population for having internalized symptoms that result in a later diagnosis and greater time for developing strategies to mask the core ADHD symptoms (Katzman et al., 2017). This raises many concerns about the untreated ADHD disorder in adults who were undiagnosed in the childhood and adolescence. The undiagnosed children and adolescents with ADHD who miss out on the early treatment may experience significant pragmatic and social difficulties, which usually lead to functional problems that may subsequently affect their education, lifestyle and occupational functioning (Salmon et al., 2016; Matthews et al., 2018).

The American Speech-Language-Hearing Association (ASHA) classifies pragmatic skills as the effective and appropriate use of language to accomplish social goals, manage turns and topics in conversation, recognition of others' conversational needs and to express appropriate degrees of politeness and awareness of social roles (2014). In the same vein, for example, Sobhani Rad (2014) defines pragmatics as an appropriate use of language either to comprehend ideas or to interact in social situations effectively. That is, pragmatics covers a broad scope of linguistic and non-linguistic communicative domains. For this reason, pragmatic language skills are difficult to measure as far as the social use of language, i.e., the dimension of pragmatics substantially depends on situational contexts, cultural norms and speakers themselves (Adams et al., 2002; Young et al., 2005). In other words, pragmatic language skills are necessary for social bonding and for everyday social life, including the formation of the context relevant to communicative intentions.

Today, besides several tests that provide a conversation and discourse assessment, like the Profile of Communicative Appropriateness (Penn, 1985), the Pragmatic Protocol (Prutting & Kirchner, 1987),

and the most common ADHD rating scales, such as, Conners' Rating Scale-IV (Conners, 1997, 2008; Conners et al., 2012), Swanson, Nolan and Pelham IV Questionnaire (SNAP-IV) (Swanson et al., 1981; Swanson, 1992), Brown ADD Rating Scales, Adult ADHD Clinical Diagnostic Scale version 1.2 (Brown, 1996), Adult ADHD Self-Report Scale (ASRS) v1.1 (Adler et al., 2006; Kessler et al., 2005), the clinical ADHD diagnostic practice most often does not include the pragmatic skill assessment tool, whereas pragmatic language skills in many individuals with ADHD are impaired and may partially account for high rates of social impairments (Staikova et al., 2013). Camarata & Gibson (1999), in their study of pragmatic language deficits in ADHD, maintain that pragmatic deficits may be associated with reduced learning opportunities, thus in case the clinically significant pragmatic deficits are detected, the intervention for these deficits should be a priority. Then, it is particularly important to study the nature and extent of pragmatic deficits in the ADHD population (Camarata & Gibson, 1999). However, it is worth pointing out that not much research has been done in this field since then. As Heyers (1995) notes, there are relative few studies directly evaluating pragmatic deficits in individuals with ADHD, and it is not surprising that intervention for ADHD as it relates to pragmatic language deficits is even rarer than assessment data. Table 1 presents the common pragmatic assessment and rating scales, which are neither adapted to the Hebrew-speaking adults, nor allow performing a comprehensive diagnostic profile of the pragmatic abilities in ADHD. All this emphasizes the need for a diagnostic tool in the field of pragmatics in the population with ADHD diagnosis.

There is a long debate about how to diagnose the communicative and linguistically based pragmatic disorder in the most appropriate way and once the social pragmatic communication disorder diagnosis has been introduced, the research to develop a formal assessment tool that targets the identification of the specific pragmatic language skill problems associated with ADHD in a cost-effective manner is needed. Of note, as Wolraich et al. (2019) point out, the consistent norm-referenced criteria for diagnosing an ongoing ADHD in adults are lacking, while previous studies emphasized the importance of the behavioral intervention for ADHD that might include measures of language including pragmatic skills (Camarata & Gibson, 1999). As it becomes evident in more recent studies, adults with ADHD experience various specific difficulties with figurative comprehension, like reaching the intended meaning of metaphors and non-literal language in general (Chahboun et al., 2021;

Table 1
Common Pragmatic Assessment and Rating Scales.

Common Pragmatic Assessment and Rating Scales	Age and/or Language	Suitable for Assessing Pragmatic Abilities in Hebrew-Speaking Adults V (Yes) / X (No)
Social cognition – Faux Pas (Baron-Cohen et al., 1999)	7 to 11 years	X
(CAPs) Clinical Assessment of Pragmatics (Lavi, 2019)	7 to 18 years	X
(TOPL-2) Test of Pragmatic Language, Second Edition (Phelps-Terasaki & Phelps-Gunn, 2007)	11 to 18 years	X
(PP)The Yale in vivo Pragmatic Protocol (Simmons et al., 2014)	9 to 17 years	X
(CADL-3) Communication Activities of Daily Living—Third Edition (Holland et al., 2019)	18 to 95 + years	X
(FACS) Functional Assessment of Communication skills (Sarno, 1969)	Adults	X
(PCA) Profile of Communicative Appropriateness (Penn, 1985)	Adults	X
(FCP) Functional Communication Profile Revised Test (Kleiman, 2014)	Adults	X

Menashe et al., 2020; Segal et al., 2017; Olofsson et al., 2014), thus, drawing particular attention to the urgent necessity in determining a brief comprehensive standardized assessment tool of pragmatic abilities in ADHD: (a). for proposing consistent norm-referenced criteria used to diagnose pragmatic deficiencies in ADHD population; and (b). for directly developing intervention programs targeting the pragmatic deficits in this population. Indeed, significant pragmatic and social difficulties, which usually lead to functional problems, are among the most common difficulties experienced by individuals with ADHD (Cordier et al., 2017; Cordier et al., 2010; Green et al., 2014). Furthermore, this close link between the pragmatic language and both social skills and ADHD (Carruthers et al., 2022) emphasizes the significant theoretical and clinical implications of the studies on pragmatic language in ADHD (Kim & Kaiser, 2000).

Today, despite the existence of evaluation batteries in English, such as the Right Hemisphere Language battery (Bryan, 1995) and the Right Hemisphere Communication battery (Gardner & Brownek, 1986), which assess the non-literal language comprehension, particularly, in patients with traumatic brain injury; and tests that provide a conversation and discourse assessment, like the Profile of Communicative Appropriateness (Penn, 1985) and the Pragmatic Protocol (Prutting & Kirchner, 1987), the clinical practice most often does not include the pragmatic skill assessment tool. The reasons for that are: (i) a language assessment is generally focused on the linguistic aspects and, thus, communicative deviations at the pragmatic level are assigned to cognitive or social deficits (Arcara & Bambini, 2016); (ii) the available pragmatic tests are generally too long, about 90 min, that is why it is difficult to administer in clinical setting; and (iii) the absence of an appropriate diagnostic tool for evaluating all aspects of pragmatic language abilities in the clinical population with ADHD.

This study evaluates a compact assessment tool of the pragmatic abilities in adults with ADHD by adopting a novel approach to the assessment of pragmatic production and pragmatic comprehension including discourse processing and understanding of humor and figurative language, based on a comprehensive approach that was originally introduced by Arcara & Bambini (2016) for the assessment of pragmatic abilities in neuro-typical individuals in Italian, and which was also found to be a reliable measure for assessing pragmatic abilities in neuro-typical Hebrew-speaking individuals (Fussman & Mashal, 2022). Integration of the discourse and non-literal language, including humor and figurative language, i.e., metaphors and idioms, in the proposed pragmatic assessment tool for identifying a particular deficit in pragmatic abilities of ADHD is evoked by the earlier findings and analysis in pragmatics which reported that ADHD individuals showed an impaired comprehension of figurative language and spoken texts (Adachi et al., 2004; Bignell & Cain, 2007; Segal et al., 2015; Olofsson et al., 2014). For example, Carruthers et al. (2022) noted a close link between pragmatic language and social skills and symptoms of ADHD further emphasizing the importance of clinical implications of studies on pragmatic language in ADHD (Kim & Kaiser, 2000). Thus, gaining a better understanding of the pragmatic profile of the ADHD is not only important for unleashing the character of pragmatic deficiencies in this population, but is also particularly essential for providing the more effectively tailored intervention programs in this clinical population.

2. Methods

This study aims at providing a detailed investigation of a pragmatic profile for Hebrew-speaking adults with ADHD by adopting the Assessment of Pragmatic Abilities and Cognitive Substrates (APACS), originally developed for Neuro-Typical population in Italian by Arcara & Bambini (2016), in order to propose a complete and cost-effective tool for the assessment of the pragmatic abilities of the Hebrew-speaking clinical population diagnosed with ADHD.

This assessment tool presents a novel and unique approach for the evaluation of pragmatic difficulties in ADHD population. First, this study

presents a systematic and a standardized evaluation of the pragmatic abilities in adults with ADHD. Second, it supports the validity of the inclusion of the pragmatic domain into the diagnostic tool for the identification of ADHD in the clinical settings for the following reasons: a). an inclusion of the major domains of impairments in a single tool, i.e., discourse and a non-literal meaning; b). a careful selection of the materials combining advanced theoretical notions in the discourse analysis and pragmatics along with the psycholinguistic variables as well as the ecological validity; and c). easiness and brevity of the implementation of the tool.

2.1. Participants

This study recruited 31 participants diagnosed with ADHD according to DSM V (excluding other neurodevelopmental or psychiatric disorders) and 88 participants with typical development as a control group, matched as possible to the ADHD group, without a history of any neurodevelopmental or psychiatric disorders according to a self-report. Participants with ADHD had a mean age of 24.35 years (SD = 2.11), 21 were males and 10 were females. The control group had a mean age of 24.56 years (SD = 3.83), 47 were males and 41 were females. The group differences on these variables were not significant at *t*-tests of age: $t(119) = 0.36$, $p = 0.72$; gender: $t(119) = 1.42$, $p = 0.16$; and field of study (profession): $t(119) = -0.62$, $p = 0.53$. In addition, a Chi-Squared Goodness of Fit Test was performed to assess if both groups can be considered significantly equivalent in terms of proportion of male/female participants and in terms of proportion of left handed/right handed participants. The results showed that both groups did not differ neither by gender [$\chi^2(1) = 1.92$, $p = 0.16$], nor by handedness [$\chi^2(1) = 2.10$, $p = 0.15$]. Additionally, a Welch test was conducted to ensure a robust comparison between the two groups. The results showed a non-significant difference, $F(1, 43) = 3.308$, $p = 0.79$, similarly to the results of a Levene's test (homogeneity of variance, $p > 0.5$), that was also provided to verify the equality of variances in the samples (Martin & Bridgmon, 2012). The participants in both groups, enrolled in this study, were from academic and medical institutions and were native speakers of Hebrew language with $IQ \geq 80$. Additionally, the severity of the symptoms of the attention deficit disorder was assessed by the Hebrew version of the Adult ADHD Self-Report (ASRS) (Zohar & Konfortes, 2010), which was based on the English version (Kessler et al., 2005). This test was chosen because of its high reliability in the test-retest and discriminate validity in the comparison to controls (Zohar & Konfortes, 2010). The participants were asked to rate in the 5-points Likert scale to what extent 18 statements concerning impulsivity, inattention and hyperactivity characterize their behavior in the everyday settings. Participants were included in the ADHD group if in addition to their clinical diagnosis, they scored above the cut-off of 51 points on ASRS, as defined in Zohar and Konfortes (2010) study.

This study has been approved by the Research Ethics Committee and a written consent was obtained prior to the administration of the research. Participants were recruited in accordance with institutional research guidelines and all participants took part in the study on a voluntary basis and after providing a written consent to participate in the research.

2.2. Procedure

This test is built up to put a particular emphasis on verbal pragmatic abilities in social communication and does not involve a role play approach which is considered to be rather a controversial one (Crockford & Lesser, 1994). The focus of the proposed test is on the use of functional communication scale, which is the best measure of communicative skills in social situations (Arcara & Bambini, 2016). The materials for construction of this assessment tool are carefully selected by using everyday language and photographs instead of drawings in order to shape pragmatic skills employed in the daily communication

processing by the individuals.

The duration of the test is 35–45 min, depending on the individuals' needs and this test does not require special training, thus, making it easy for the administration. This test includes two pragmatic domains, i.e., discourse and a literal language, which are devoted to assess the PRODUCTION and COMPREHENSION in 6 tasks: interview; description; narratives; figurative language 1 (familiar idioms, novel metaphors and common proverbs presented in a minimal context); humor; and figurative language 2 (verbal explanation of familiar idioms, novel metaphors and common proverbs).

In the **First Section** - PRAGMATIC PRODUCTION includes the two tasks, which are set to administer for approximately 10 min:

The first task, *Interview*, evaluates the ability of engaging in a conversation in relation to the communicative effectiveness and discourse parameters, in terms of rating the presence of the communicative difficulties, for example: anomia, agramatism, phonemic paraphasias, semantic paraphasias, circumlocutions, repetitions/passepartout expressions, incomplete sentences, echolalia, coprolalia, difficulty with yes/no answers, tendency to be under-informative or over-informative, the lack or wrong use of cohesive ties or discourse referents, abrupt topic shift or wrong order of narrative elements, altered intonation or speech rate, the lack of visual contact, fixed facial expression or abuse of compensatory gestures. All items were scored as (0) – missed, (1) – partial, or (2) – correct identification with the maximum score of 48 in this task.

The second task, *Description*, assesses the ability of sharing the information of different everyday life situations and producing informative and relevant description. In this task the participants are shown 10 photographs which they are asked to describe, i.e., to name the salient elements in the scene, such as the main agent in the photograph, the action that is performed by the main agents and their location. All items were scored as (0) – always, (1) – sometimes, or (2) – never with the maximum score of 44 in this task.

In the **Second Section** - PRAGMATIC COMPREHENSION includes the four tasks, which are set to administer for approximately 25–35 min:

The first task in the second section, *Narratives*, evaluates the ability of discourse comprehension and understanding of the major aspects of the narrative texts, composed of 4–8 sentences which include two non-literal expressions. Six stories, that are read to the participants at a normal rate, are followed: by one open question for assessing the comprehension of the main topic of each story; then by two to four yes/no questions for assessing the comprehension of the specific aspects of the narrative either explicitly stated or implied; and, finally, by two open questions assessing the comprehension of the non-literal expressions presented in the context. All items were scored either correct – (2), partially correct – (1) or incorrect – (0) with the maximum score of 56 in this task.

The second task in this section, *Figurative Language (1)*, evaluates the ability of inferring the non-literal meaning through the multiple-choice questions. The participants are presented with fifteen items, including highly familiar idioms, novel metaphors and common proverbs from a dictionary of Hebrew proverbs, in a minimal context with three possible interpretations for each item in which only one option presents a correct figurative interpretation of the targeted expression. All items were scored either correct – (1) or incorrect – (0) with the maximum score of 15 in this task.

The third task in the second section, *Humor*, evaluates the ability of comprehending verbal humor presented in the seven multiple-choice questions. Each item presents a short story in 2–3 sentences with three possible endings and the participant is asked to choose a correct funny ending that functions as a punchline. A correct funny ending – scored (1) and an incorrect straightforward non-funny ending and an incorrect unrelated ending – scored (0), with the maximum score of 7 in this task.

The fourth task in the second section, *Figurative Language (2)*, evaluates the ability to infer the non-literal meanings of fifteen items (five highly familiar idioms, five novel metaphors and five common proverbs

from a dictionary of Hebrew proverbs) provided in a minimal context, similarly to the second task with *Figurative Language (1)*, but in the last task the participants are required to provide a verbal explanation of each non-literal expression. All items were scored as a correct answer – (2), if the participant provided an acceptable description of the figurative meaning; as a partially correct answer – (1), if the participant provided an incomplete description of the figurative meaning, i.e., providing a concrete example rather than general meaning of the figurative expression/sentence; or incorrect answer – (0), if the participant provided a literal meaning, paraphrased or did not know the meaning of the figurative expression/sentence, with the maximum score of 30 in this task.

It is worth pointing out an easy scoring system and the administration of this assessment tool, which does not require an effortful training of clinicians. Three composite scores are computed from the six task scores. The composite score for the Pragmatic Production is computed from the *Interview* and *Description* task scores. The composite score for the Pragmatic Comprehension is computed from the *Narrative*, *Figurative Language 1*, *Humor* and *Figurative Language 2* task scores. These composite scores are obtained after transforming the original task scores in proportion to the other tasks and averaging the obtained proportions. The total score of the APACS battery is calculated by averaging the composite scores of the Pragmatic Production and Comprehension. That is, this study presents a compact test kit that can be an essential contribution in the pragmatic diagnostics for detecting the specific impairments in the pragmatic competence of the individuals with ADHD, which is essential for the efficient communication, social and academic functioning.

3. Results

3.1. Pairwise comparison of ADHD and TD groups in pragmatic performance

Descriptive statistics and *t*-test comparing ADHD and TD participants' results on APACS tasks and composite scores are reported in [Table 2](#). The comparative analysis of the results by both groups showed a significant difference between the TD and ADHD groups in the APACS total score $t(119) = -1.82, p = 0.04$. Similarly, the Narratives $t(119) = -2.52, p = 0.01$ and Figurative Language 2 tasks $t(119) = -3.12, p < 0.01$ showed a significant difference in the performance by both groups, which is also reflected in the marginally significant composite score of the pragmatic comprehension $t(119) = -1.98, p = 0.05$. The statistical results of the comparative analysis of the ADHD and TD scores on APACS tasks and composite scores are presented in [Fig. 1](#).

3.2. Effect of demographic variables on APACS tasks and composite scores by ADHD and TD groups

To determine the effect, the various demographic variables have on each of the tasks and on the composite score, several linear regression analyses have been performed. In total, there were found significant effects of age almost in all tasks for ADHD, i.e., age was significant for Description, Narratives, Pragmatic Production, Pragmatic Comprehension and APACS Total in the ADHD group, while it was not significant in the TD group. Conversely, no significant effect of Education was found in the ADHD group, while in the TD group, Education had a significant effect on the Interview scores. Gender had a statistically significant effect on the Pragmatic Production in the ADHD group and also had a significant effect on the Interview in the TD group. Several professions, like profession 2: visual communication; profession 3: practical engineering; profession 8: economics, management, psychology; and profession 9: academic preparatory program, had significant effects on some of the APACS tasks and composite scores, as can be seen in [Table 3a](#) and [Table 3b](#). The linear correlation between age, education and the different tasks and composite APACS scores are presented in

Table 2
Descriptive statistics and results for *t*-test comparing ADHD and TD groups in the pragmatic assessment.

	Total Mean	ADHD Mean	(SD)	TD Mean	(SD)	df	t	p-value
Interview	43.01	42.61	(1.69)	43.15	(1.14)	40.08	-1.64	0.10
Description	41.81	40.77	(7.86)	42.18	(5.67)	41.51	-0.92	0.28
Narratives	48.42	46.97	(3.75)	48.93	(3.72)	52.28	-2.52	0.01
Figurative Language 1	13.75	13.84	(0.93)	13.72	(1.66)	93.84	0.50	0.69
Humor	6.64	6.71	(0.59)	6.61	(0.72)	63.69	0.74	0.50
Figurative Language 2	20.01	18.00	(4.03)	20.72	(4.56)	59.05	-3.12	< 0.01
Pragmatic Production	0.92	0.91	(0.09)	0.93	(0.07)	41.55	-1.19	0.24
Pragmatic Comprehension	0.85	0.83	(0.06)	0.86	(0.07)	56.24	-1.98	0.05
APACS Total	0.89	0.87	(0.07)	0.89	(0.05)	43.49	-1.82	0.04

The table shows the *t*-test results for the individuals with ADHD and controls on the APACS tasks, APACS composite scores and the APACS total score. The first column reports the name of the APACS task, the composites APACS scores and APACS total score. The second column reports the Total mean of individuals with ADHD and controls. The third and the fifth columns report the mean of individuals with ADHD and controls. The fourth and the sixth columns report the SD of individuals with ADHD and controls. The seventh column reports the degrees of freedom associated with the *t*-test. The eighth column reports the *t*-values and the ninth column reports the *p*-values.

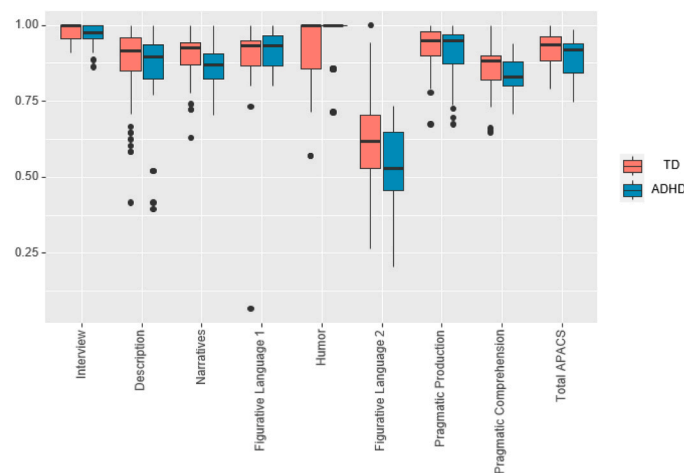


Fig. 1. APACS tasks and composite scores of the TD(Control) and ADHD groups. Fig. 1 presents the performance of individuals with ADHD and controls in pragmatic tasks, composite scores and APACS total score. All raw scores were transformed in proportion (relative to the maximum obtained score) before plotting. Green boxplots indicate the mean performance of individuals with ADHD, while orange boxplots indicate the mean performance of individuals with typical development (controls).

Fig. 2.

Correlations between the study variables for the ADHD and TD group (i.e., correlations between continuous demographic variables, each of the tasks and the composite score) are presented in Table 4a and Table 4b. In the ADHD Group, the Figurative Language 2 task was strongly correlated with the Description task ($r = 0.48, p < 0.01$), the Narratives task ($r = 0.6, p < 0.01$) and the Figurative Language 1 task ($r = 0.47, p < 0.01$). In addition, correlations were also found between the Interview and the Narratives task ($r = 0.41, p = 0.02$), as well as between the Interview and the Humor task ($r = 0.42, p = 0.02$). The Description task was the mostly correlated with the composite score in Pragmatic Production ($r = 0.98, p < 0.01$), whereas the Figurative Language 2 task was the mostly correlated with the composite score in Pragmatic Comprehension ($r = 0.9, p < 0.01$). Moreover, these two tasks were also the most highly correlated with APACS total ($r = 0.87$ and $r = 0.77$ respectively, $p < 0.01$ for both). Age was correlated with the Description task ($r = 0.52, p < 0.01$) as well as with the composite score in Pragmatic Production ($r = 0.52, p < 0.01$) and with the APACS total score ($r = 0.47, p < 0.01$) in the ADHD group. In the TD group, age was only correlated with the Interview task ($r = 0.28, p < 0.01$), whereas education was correlated with the Interview task ($r = 0.31, p < 0.01$), the composite score in Pragmatic Comprehension ($r = 0.23, p = 0.03$) and the APACS total score ($r = 0.28, p < 0.01$). It is worth

noting that the composite scores in Pragmatic Production and Pragmatic Comprehension showed a significant correlation in the ADHD Group ($r = 0.46, p < 0.01$), but were not correlated in the TD group. . .

3.3. Factorial structure and internal consistency

The internal consistency for the APACS was calculated using McDonald’s omega (ω) for several reasons, first, as far as the data might have a hierarchical or multidimensional internal structure, as it is expected from the structure of the test which is composed of pragmatic production and pragmatic comprehension tasks, and, second, since omega does not require as many assumptions as Cronbach’s α , i.e., it is not influenced by the number of items as α does (Hayes & Coutts, 2020). The results of the computed omega indicated a good internal reliability ($\omega = 0.68$) of the different APACS tasks (i.e., ‘interview’, ‘description’, ‘narratives’, ‘figurative language 1’, ‘humor’, and ‘figurative language 2’).

Furthermore, all APACS tasks: Interview, Description, Narrative, Figurative Language 1, Humor and Figurative Language 2 tasks were subjected to an exploratory factorial analysis with varimax rotation, which was computed using 2-factor inner structure for the sample size ($N = 119$) (see Table 5). The Kaiser-Meyer-Olkin (KMO) measure portrayed a result of 0.64 and Bartlett’s test of sphericity $\chi^2 = 75.2, p < 0.001$, with total variance explained by Rotation Sums of Squared Loadings of 51.94%, indicating inner correlations between the tasks, being sufficient for factor analysis.

The two-factor analysis shows that the first factor is presumably associated with the tasks evaluating pragmatic performance that include open-ended questions, being correlated with Interview, Description, Narratives and Figurative Language 2. The highest loadings for the second factor are associated with the pragmatic comprehension of the figurative language and humor, being correlated with the Figurative Language 1 and Humor tasks, which include multiple-choice questions. These results for both groups in the factorial analysis are presented in Fig. 3.

In order to study whether there are differences in the factorial loadings between the TD and ADHD samples, the exploratory factor analysis with varimax rotation was performed separately for both samples. For the ADHD sample ($N = 31$), the KMO measure portrayed a result of 0.65, and Bartlett’s test of sphericity $\chi^2 = 42.45, p < 0.001$, with total variance explained by Rotation Sums of Squared Loadings of 65%, indicating inner correlations between the tasks, which is sufficient for the factor analysis. The results of this two-factor analysis for the ADHD sample, reported in Table 6, show that the first factor is presumably associated with the tasks, being correlated with Description, Narratives, Figurative language 1 and Figurative Language 2, which are associated with production of the informative and relevant description of everyday life situations, discourse comprehension and inferring the

Table 3a
Effect of demographic variables on APACS tasks and composite scores for ADHD group.

Task or composite score	Term	Estimate	Standard Error	t-value	p-value	Model R ²
Interview	(Intercept)	35.80	5.62	6.37	< 0.001 *	0.13
	Profession2	-4.73	1.71	-2.76	0.01 *	
Description	(Intercept)	-10.47	20.51	-0.51	0.62	0.47
	Age	2.17	0.54	4.04	< 0.001 *	
	Profession8	-18.38	6.13	-3.00	0.01 *	
Narratives	(Intercept)	33.85	10.45	3.24	< 0.001 *	0.39
	Age	0.96	0.27	3.51	< 0.001 *	
	Profession3	-6.52	2.27	-2.87	0.01 *	
	Profession9	-4.86	1.61	-3.01	0.01 *	
Figurative Language 1			No significant variables			
Humor			No significant variables			
Figurative Language 2			No significant variables			
Pragmatic Production	(Intercept)	0.30	0.24	1.27	0.22	0.46
	Gender2	0.07	0.03	2.13	0.04 *	
	Age	0.03	0.01	4.17	< 0.001 *	
	Profession8	-0.20	0.07	-2.81	0.01 *	
Pragmatic Comprehension	(Intercept)	0.54	0.19	2.85	0.01 *	0.25
	Age	0.01	0.00	2.63	0.02 *	
	Profession9	-0.07	0.03	-2.55	0.02 *	
	Profession9	-0.07	0.03	-2.55	0.02 *	
Total APACS	(Intercept)	0.42	0.18	2.37	0.03 *	0.42
	Age	0.02	0.00	4.18	< 0.001 *	
	Profession9	-0.06	0.03	-2.16	0.04 *	

Table 3a reports the results for the ADHD group: the task and APACS composite score name (first column), name of the term in the regression model (second column), coefficient estimate (third column), standard error (fourth column), t-value associated with term (fifth column), p-value with star “*” denoting significant terms (sixth column), and adjusted R² (eighth column).

Table 3b
Effect of demographic variables on APACS tasks and composite scores for TD group.

Task or composite score	Term	Estimate	Standard Error	t-value	p-value	Model R ²
Interview	(Intercept)	39.39	1.15	34.17	< 0.001 *	0.31
	Gender2	0.72	0.23	3.09	< 0.001 *	
	Education	0.20	0.09	2.18	0.03 *	
	Profession3	-2.45	0.56	-4.35	< 0.001 *	
Description	(Intercept)	38.15	6.57	5.80	< 0.001 *	0.09
	Profession9	-8.54	2.37	-3.60	< 0.001 *	
Narratives	(Intercept)	44.31	4.17	10.62	< 0.001 *	0.15
	Profession2	-5.78	1.35	-4.29	< 0.001 *	
Figurative Language 1			No significant variables			
Humor			No significant variables			
Figurative Language 2	(Intercept)	20.36	5.55	3.67	< 0.001 *	0.00
	Profession3	-5.76	2.71	-2.13	0.04 *	
Pragmatic Production	(Intercept)	0.84	0.07	11.56	< 0.001 *	0.13
	Profession9	-0.10	0.03	-3.71	< 0.001 *	
Pragmatic Comprehension			No significant variables			
Total APACS	(Intercept)	0.83	0.06	14.47	< 0.001 *	0.13
	Profession9	-0.07	0.02	-3.36	< 0.001 *	

Table 3b reports the results for the TD group: the task and APACS composite score name (first column), name of the term in the regression model (second column), coefficient estimate (third column), standard error (fourth column), t-value associated with term (fifth column), p-value with star “*” denoting significant terms (sixth column), and adjusted R² (eighth column).

non-literal meaning. The highest loadings for the second factor, being correlated with the Interview and Humor tasks, are associated with the engagement in a conversation and comprehension of verbal humor. .

For the TD sample (N = 88), the KMO measure portrayed a result of 0.61, and Bartlett’s test of sphericity $\chi^2 = 39.79, p < 0.001$, with total variance explained by Rotation Sums of Squared Loadings of 50%, indicating inner correlations between the tasks, sufficient for factor analysis. The results of this TD sample analysis, reported in Table 7, support the factorial structure of the APACS model presented in Fig. 3. That is, the first factor loadings, being correlated with the Interview, Description, Narratives and Figurative Language 2 tasks, are presumably associated with the tasks that include open-ended questions, whereas the highest loadings for the second factor, being correlated with the Figurative Language 1 and Humor tasks, are associated with the pragmatic comprehension of the figurative language and humor that include

multiple-choice questions.

The obtained results from the explanatory factor analysis that was performed on each group showed some subtle structure differences, which presumably underpin the underlying differences in the pragmatic function of both groups.

3.4. Cut-offs and sensitivity on APACS tasks and composite scores

Cut-off values computed as 5th percentile of the control matched sample, as presented in Fig. 4, were calculated for all APACS tasks and for the APACS composite scores (for an analogous approach, see Bambini et al., 2016). For each task, the graph shows the percentage of ADHD subjects with a score lower than the 5th percentile score of the control group. The results show that for the ADHD group, the sensitivity for APACS total was 19.4%; the sensitivity for Pragmatic

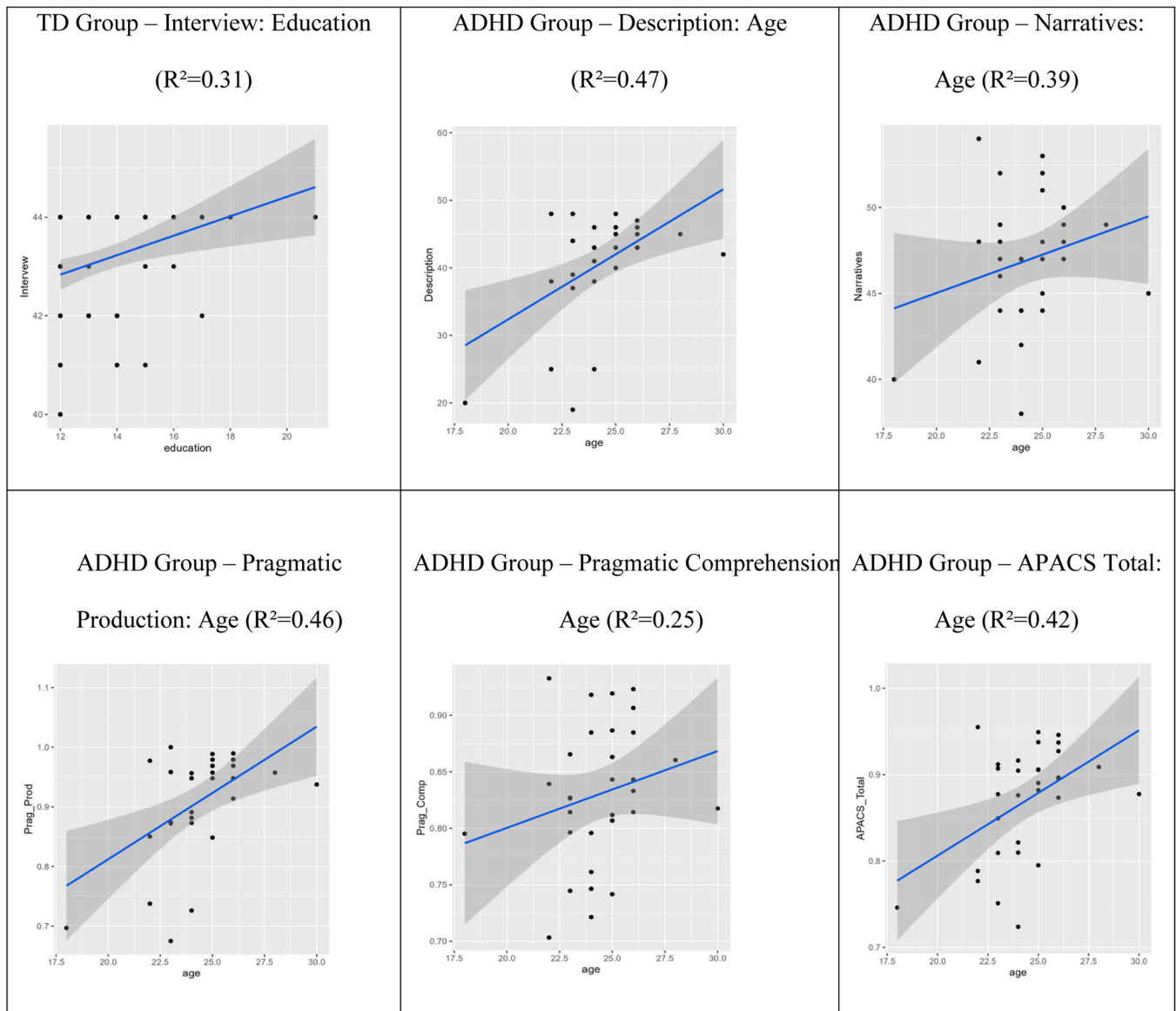


Fig. 2. Effect of age and education on tasks and composite scores for both groups. Fig. 2 reports the effect of age and education on APACS tasks and composite scores as estimated by regression analysis. The line represents the predicted score at the task according to the independent variable and the dots present the observed performance by individuals.

Table 4a
Correlations between study variables – ADHD Group.

	1	2	3	4	5	6	7	8	9	10	11
1. Interview	1										
2. Description	0.29	1									
3. Narratives	0.41 *	0.35	1								
4. Figurative Language 1	-0.04	0.23	0.33	1							
5. Humor	0.42 *	-0.01	0.19	-0.15	1						
6. Figurative Language 2	0.30	0.48 **	0.60 **	0.47 **	0.23	1					
7. Pragmatic Production	0.48 **	0.98 **	0.41 *	0.20	0.08	0.50 **	1				
8. Pragmatic Comprehension	0.41 *	0.41 *	0.75 **	0.55 **	0.48 **	0.90 **	0.46 **	1			
9. APACS Total	0.52 **	0.87 **	0.64 **	0.40 *	0.28	0.77 **	0.91 **	0.79 **	1		
10. Age	0.24	0.52 **	0.25	0.28	0.03	0.15	0.52 **	0.23	0.47 **	1	
11. Education	0.13	0.08	-0.15	0.03 s	0.04	0.09	0.10	0.03	0.08	0.11	1

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

Comprehension was 16.1%, and the sensitivity for Pragmatic Production, as well as for the Interview, Description and Narratives tasks was 12.9%. For figurative Language 2 the sensitivity was only 6.5% and no

subjects had a lower than the 5th percentile threshold for Figurative Language 1 and Humor in this sample. As can be seen in Fig. 1, the distribution for these tasks is not quite different in both the ADHD and

Table 4b
Correlations between study variables – TD Group.

	1	2	3	4	5	6	7	8	9	10	11
1. Interview	1										
2. Description	0.33 **	1									
3. Narratives	0.22 *	0.14	1								
4. Figurative Language 1	-0.04	-0.09	0.07	1							
5. Humor	0.15	0.02	-0.01	0.12	1						
6. Figurative Language 2	0.26 *	0.26 *	0.34 **	0.10	0.19	1					
7. Pragmatic Production	0.50 **	0.98 **	0.17	-0.09	0.05	0.29 **	1				
8. Pragmatic Comprehension	0.25 *	0.16	0.47 **	0.54 **	0.54 **	0.78 **	0.19	1			
9. APACS Total	0.48 **	0.73 **	0.42 **	0.30 **	0.39 **	0.69 **	0.77 **	0.78 **	1		
10. Age	0.28 **	0.07	0.13	0.02	0.06	0.03	0.12	0.08	0.13	1	
11. Education	0.31 **	0.15	0.20	0.16	0.12	0.11	0.20	0.23 *	0.28 **	0.64 **	1

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

Table 5
Results of factor analysis on APACS tasks.

Task	Factor 1 - loading	Factor 2 - loading
Interview	0.71	0.00
Description	0.70	-0.19
Narratives	0.66	0.20
Figurative Language 1	-0.09	0.82
Humor	0.15	0.55
Figurative Language 2	0.70	0.34

This table reports the factor loadings for the APACS tasks for both groups, after a factor analysis with varimax rotation.

TD group, which explains the low sensitivity for these two tasks using this threshold.

3.5. Prediction of pragmatic performance of ADHD with random forest analysis

Random Forest Analysis was used to study the Importance associated with each predictor in the model. Importance highlights how each model predicts subject classification as having a task score above or below the control 5th percentile.

In the Random Forest analysis with Pragmatic Production as a dependent variable, the Description task was substantially more important than the other predictors according to mean decrease in Gini when removing the variable. Age and Profession were more important as predictors than ASRS, but ASRS was more important than Interview. The

Importance of all predictors for the Pragmatic Production model is depicted in Fig. 5.

In the Random Forest analysis with Pragmatic Comprehension as a

Table 6
Results of factor analysis for ADHD group on APACS tasks.

Task	Factor 1 - loading	Factor 2 - loading
Interview	0.29	0.78
Description	0.66	0.10
Narratives	0.73	0.34
Figurative Language 1	0.73	-0.38
Humor	-0.02	0.83
Figurative Language 2	0.84	0.22

This table reports the factor loadings for the APACS tasks for the ADHD group, after a factor analysis with varimax rotation.

Table 7
Results of factor analysis for TD group on APACS tasks.

Task	Factor 1 - loading	Factor 2 - loading
Interview	0.72	-0.03
Description	0.69	-0.26
Narratives	0.56	0.20
Figurative Language 1	-0.12	0.79
Humor	0.17	0.59
Figurative Language 2	0.66	0.37

This table reports the factor loadings for the APACS tasks for the TD group, after a factor analysis with varimax rotation.

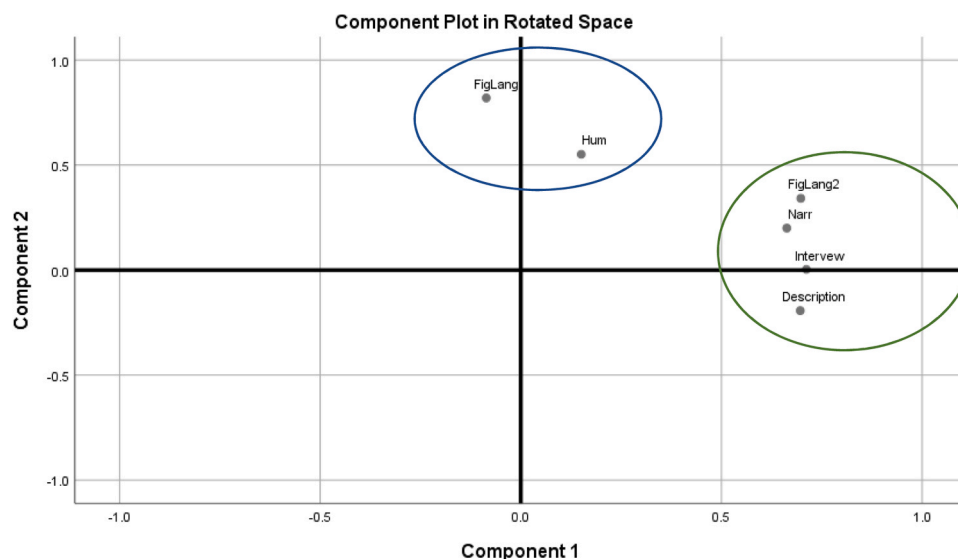


Fig. 3. Two-factor loading of APACS tasks.

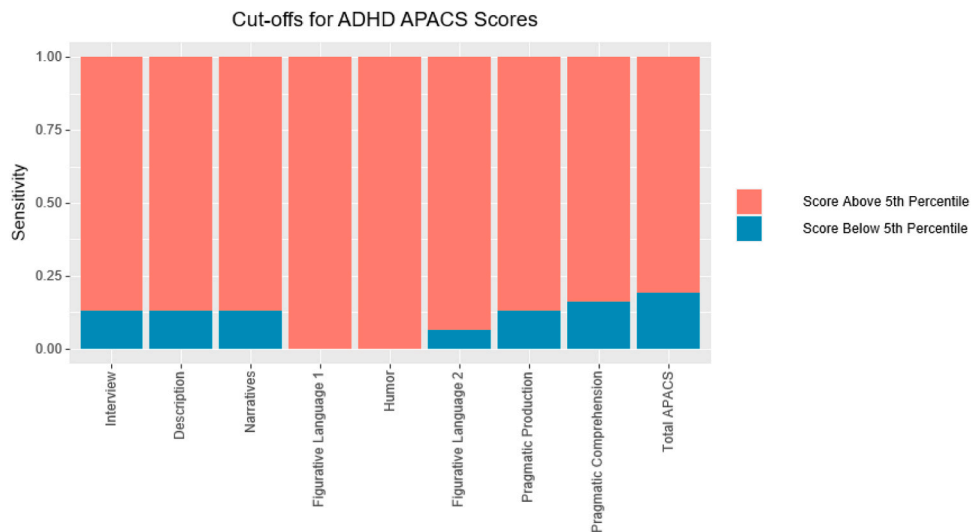


Fig. 4. Performance below cut-off of individuals with ADHD in APACS pragmatic tasks and composite Scores. This figure shows percentage of individuals with ADHD who scored below cut-off (i.e., below 5th percentile of control data) in the APACS tasks and in the APACS composite scores. Each column denotes a task/composite score: green color indicates a performance below cut-off, whereas orange color indicates a performance above cut-off.

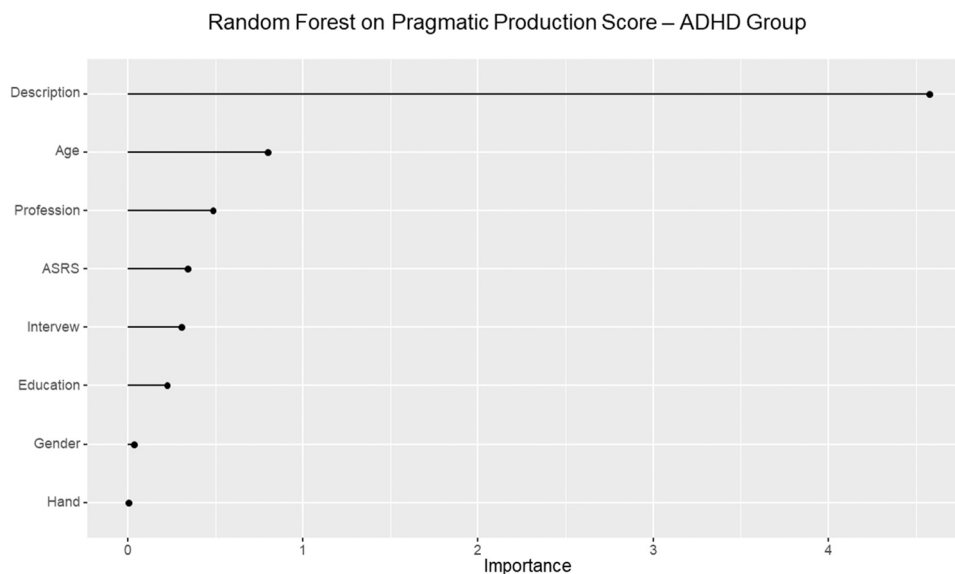


Fig. 5. Random Forest on Pragmatic Production. This figure shows the Importance associated with each variable in the random forest analysis on the APACS Pragmatic Production score as a dependent variable. Variables are sorted from top to bottom according to Importance, so the variables, being on top, are with the highest Importance.

dependent variable, the Figurative Language 2 task was found to be the most significant predictor than the Narratives, Humor and Figurative Language 1 tasks. The magnitude of the ADHD self-report symptoms in the ASRS has been also found to be an important predictor of the Pragmatic Comprehension, though with less significant Importance than the Figurative Language 2 variable. The Importance of all predictors for Pragmatic Comprehension model is depicted in Fig. 6.

4. Discussion

This study provides an innovative insight into the complex disorder, such as ADHD, in general, and proposes a valuable and feasible way for advancing an appropriate evaluation of the pragmatic deficiencies in this population, in particular. The current study presents the pragmatic diagnostic characteristics of ADHD individuals, using a comprehensive assessment tool (APACS, Acara & Bambini, 2016; APACS-Heb, Fussman & Mashal, 2022), which evaluates pragmatic abilities in both domains:

pragmatic production and pragmatic comprehension and allows the evaluation of the pragmatic competence by considering a non-literal language and discourse in a set of six tasks. The reported results demonstrate that APACS presents a good reliability with internal consistency for all tasks (McDonald’s omega $\omega > 0.68$) and demonstrates the psychometric properties for the assessment of the pragmatic abilities in the Hebrew-speaking adults aged 18–30 with ADHD. At the group level, individuals with ADHD showed a worse performance than their matched controls in the APACS total score, in general, and in the composite score of Pragmatic Comprehension and the pragmatic comprehension tasks: Narratives and Figurative Language 2, in particular. These significant differences in the pragmatic performance of the TD and ADHD groups, as presented in Table 2, point to the characteristic pragmatic deficits in the ADHD, i.e., deficiencies in the pragmatic performance of ADHD subjects, and in the comprehension tasks of the Figurative Language 2 and Narratives, which may be viewed as a significant predictor of the pragmatic deficits in individuals with ADHD. It

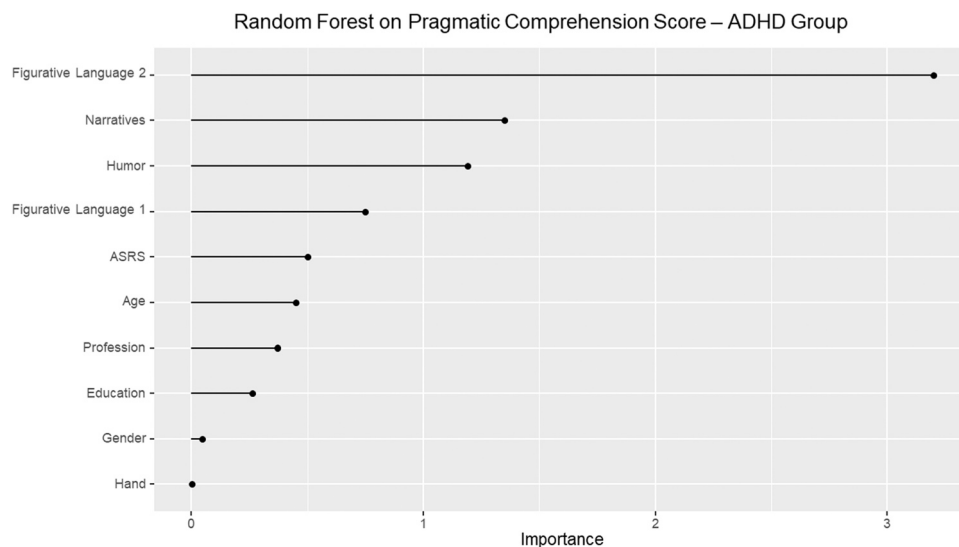


Fig. 6. Random Forest on Pragmatic Comprehension. This figure shows the Importance associated with each variable in the random forest analysis on the APACS Pragmatic Comprehension score as a dependent variable. Variables are sorted from top to bottom according to Importance, so the variables, being on top, are with the highest Importance.

is worth pointing out that no significant difference in the pragmatic comprehension tasks of Figurative language 1 and Humor, which assessed an understanding of the non-literal language and humor via the presented to the participants multiple-choice options, was found. These results support the earlier findings by Kim and Kaiser (2000) who report a better performance of the individuals with ADHD when alternative responses are provided than when they are required to retrieve their own response.

The effect of demographic variables on each of the tasks and on the composite score was studied by performing several regression analyses. The study of the effect of the demographic variables on the pragmatic production and comprehension in the individuals with ADHD has shown a significant correlation of age for several tasks, i.e., for Description and Narratives, and all the composite scores of APACS, i.e., Pragmatic Production, Pragmatic Comprehension and APACS total, whereas in the TD group no significant effect of age was found. Conversely, in the TD group a significant correlation of education was found for the Interview task, while no significant effect was found in the ADHD group. Interestingly, gender has shown a similar effect on the pragmatic production in both groups; however, while in the ADHD group a significant correlation of gender was found on the composite score of Pragmatic Production, in the TD group a high correlation was found on the specific task of the pragmatic production, i.e., the Interview task. These findings suggest an overall important effect of the gender variable on the pragmatic performance. On the other hand, the results of the demographic variables like education and age have shown diametric modes. Education has been found to have a substantial effect on the pragmatic production, specifically in the Interview task in the individuals with neurotypical development, while age has been found to have an important effect on the Pragmatic Production and Pragmatic Comprehension in the ADHD group. Furthermore, the analysis of the correlations between the study variables revealed significant differences in the correlations of Pragmatic Production and Pragmatic Comprehension, pointing to the significant correlation effect in the ADHD group in comparison to the TD group, thus sustaining that correlation between task variables and composite scores might be viewed as a characteristic aspect of the ADHD.

Additionally, as for the demographic variables, the results of the regression analysis revealed a significant positive effect of age on the APACS tasks and the composite scores only in the ADHD group, i.e., the older participants had significantly higher grades on the Description and Narratives task, as well as on the composite scores of the Pragmatic

Production, Pragmatic Comprehension and APACS total. The presented results are consistent with the preceding findings concerning the neuropsychological tests (Strauss et al., 2006) and are in line with the previous studies that suggest an unequivocal effect of age in ADHD on certain pragmatic abilities which are crucial for the effective communication (Cordier et al., 2013), like in response to metaphors (Bonnaud et al., 2002; Mejía-Constaín et al., 2010), narrative comprehension (Szaflarski et al., 2012) and comprehension of jokes (Mak & Carpenter, 2007). More support in this matter comes, for example, from a longitudinal fMRI study on narrative comprehension of healthy individuals by Szaflarski et al. (2012), who reported a delayed maturation of narrative processing skills, indicating once again that these skills may be delayed in individuals with ADHD. On the other hand, the results obtained from the TD group revealed a positive effect of education on the semi-structured clinical Interview task score in the TD group, thus supporting the earlier finding concerning the effectiveness of education on the development of the communication skills in typically developing individuals (Okita, 2012). Similarly, Willinger et al. (2019) reported on an ongoing development of figurative language comprehension and metaphorical language abilities which reach a plateau in adulthood (Nippold et al., 1997) and then remain stable in elderly subjects with high education (Bonnaud et al., 2002; Arcara & Bambini, 2016).

Further evidence of the age effect in the ADHD comes from the brain studies. The pragmatic performance might be affected by age as far as the symptoms of impulsivity and hyperactivity decline with age as ADHD individuals reach adulthood (Biederman et al., 2000). Shaw et al. (2007, 2012) depicted a considerable delay in the prefrontal cortical development in ADHD in comparison with the neurotypicals, which may explain the influence of age on the pragmatic performance in ADHD individuals. The results of the current study, concerning the significant effect of education on the pragmatic performance in TD individuals, provide a further support to the earlier finding of a direct influence of the development of higher-order cognitive skills associated with a better social perception and better pragmatic skills in the individuals with typical development rather than in ADHD individuals (Cardillo et al., 2023). The presented findings demonstrate a potential contribution of the further study of the cognitive substrates of pragmatics that can serve as a complementary assessment tool of pragmatic abilities, proceeded with the neuropsychological tests for the evaluation of the social cognition and executive functions.

An exploratory factorial analysis with varimax rotation was performed to explore the factorial structure of the pragmatic production

and comprehension tasks of the APACS model: Interview, Description, Narratives, Figurative Language 1, Humor, Figurative Language 2. The factorial analysis of the entire sample revealed the pattern of two factors that may account for task variance. The first factor with the highest loadings in Interview, Description, Narratives and Figurative Language 2 is associated with the pragmatic production and retrieving implicitly or explicitly the presented information and non-literal meaning. The common feature of all these loadings is that all these tasks are constructed as the open-ended questions. The second factor revealed the highest loadings for Humor and Figurative Language 1, which are associated with the pragmatic processes in comprehending humor and non-literal meanings, all of which are presented as the multiple-choice questions. Similar results were obtained in the factorial analysis of the TD sample, which also match the findings reported in [Arcara and Bambini \(2016\)](#) regarding the factor analysis of the normative data in Italian. Innovatively, in addition to the factorial analysis of the normative data, the current study examined the factorial analysis for the ADHD group to explore the differences in the pragmatic performance in the TD and ADHD groups. The results of the factor analysis for ADHD group revealed two main loadings. The first factor with the highest loadings for Description, Narratives, Figurative language 1 and Figurative Language 2, which are associated with producing informative and relevant description of everyday life situations, discourse comprehension and inferring the non-literal meaning, and the second factor for the Humor and Interview tasks, which are associated with the comprehension of verbal humor and the engagement in a conversation. This factorial model is consistent with the previous findings of the factorial structure for APACS-Heb observed in typically developing adolescents ([Fussman & Mashal, 2022](#)), suggesting that similar neural mechanisms might underlie the specific pragmatic processes in both populations: typically developing adolescents and adults with ADHD. These results support the construct validity of APACS as a tool that captures different aspects of the pragmatic competence, possibly related to different cognitive substrates, the underlined mechanisms of which might be affected by the divergent neurodevelopmental stages, thus further confirming the view of a non-monolithic module of pragmatics. Moreover, the current results demonstrate that the specific pragmatic processes are involved across the different types of the pragmatic tasks and these processes might be sensitive and might identify not only the neurodevelopmental stage of an individual, but also might potentially distinguish a neurotypical from neuro-atypical pragmatic processing in the targeted population. Importantly, the presented results are in line with the previous findings which suggest two separate cognitive resources are relied in the comprehension of humor and figurative language that include the process of retrieving a non-literal meaning. That is, while Humor, associated with the second factor, reflects the pragmatic processes involved in the comprehension of humor and in the monitoring the protagonists' perspectives implied in the narratives, might be linked to Theory of Mind and social cognition in inferring the speaker's conveyed messages via irony or sarcasm ([Vrticka et al., 2013](#)); Figurative Language 2, associated with the first factor, refers to the ability to interpret figurative language, including metaphors, proverbs and idioms, that might be linked to the executive functions like an inhibition of inappropriate literal meaning ([Papagno & Romero Lauro, 2010](#)). However, it is worth pointing out that this is one way of interpreting these findings and a further empirical examination is needed to sustain these hypotheses.

Besides the factorial analysis, the computational study of the pragmatic abilities of the ADHD individuals was performed to obtain the data on the cut-off scores of the ADHD participants, who scored below 5th percentile of the control (TD) group. It is important to note that the results showed a higher sensitivity effect in the ADHD group for Pragmatic Comprehension, which included the discourse and non-literal language comprehension tasks, rather than for Pragmatic Production. These results support the previous findings on the specific difficulties in understanding a non-literal language and comprehension of spoken texts in ADHD ([Carruthers et al., 2022](#); [Chahboun et al., 2021](#); [Crespo](#)

[et al., 2007](#); [Parks et al., 2023](#)), probably, because of the poorer verbal working memory in the individuals with ADHD compared to the individuals with typical development ([McInnes et al., 2003](#)).

Moreover, Random Forest analysis demonstrates a very clear-cut link between the pragmatic production abilities of the individuals with ADHD and, particularly, the skills that involve describing or sharing information on the main elements of everyday situations, and effect of age. These observations are in line with the high correlations identified for the pragmatic production and age in the ADHD group, suggesting that pragmatic abilities in ADHD may be significantly improved in young adulthood similarly to pragmatic comprehension abilities ([Saban-Bezael & Mashal, 2019](#)). In the same vein, the Random Forest analysis, in predicting Pragmatic Comprehension, demonstrates the significant effect of the age variable on predicting the Pragmatic Comprehension score in ADHD. These findings are consistent with the previous studies that point to the development of the comprehension abilities, specifically, the understanding of the figurative language ([Nippold et al., 1997](#)). Unsurprisingly, the task of the Figurative Language 2, which presupposes the comprehension and explanation of the non-literal meaning, was found to be among the highest variables in terms of the Importance scale in the Forest Analysis predicting Pragmatic Comprehension performance in ADHD group, and the Narratives task was found to be a subsequent predictor after the Figurative Language 2, in terms of the Importance scale. These results are consistent with the earlier findings that individuals with ADHD not only demonstrate less social reciprocity and inappropriate initiations, but also experience difficulties in understanding non-literal language and provide less coherent narratives ([Carruthers et al., 2022](#)), difficulties that probably stem from the underlying deficiencies in working memory ([Papaeliou et al., 2012](#)). However, this theoretical assumption requires a further empirical and systematic study.

Finally, the findings, presented in this study, depict a potential feasibility of the psychometric properties of APACS as a useful tool that can be employed for clinical and research purposes. Furthermore, a relatively short duration of the test, about 35–45 min, and the scoring system which does not require special training, makes it easy for administration in clinical settings. APACS is built up to put a particular emphasis on the verbal pragmatic abilities in social communication and does not involve a role play approach which is considered to be rather a controversial one. The focus of this test is on the use of a functional communication scale which is the best measure of communicative skills in social situations ([Acara & Bambini, 2016](#)), since it can provide a comprehensive assessment of the pragmatic competence in this clinical population. Moreover, the clinical utility of APACS in ADHD population may be explained by the following: a) individuals with ADHD show impairments in the psychosocial functioning vital for the appropriate communication and social life of an individual ([Okumura et al., 2021](#)), and b) the expanded number of clinical populations with pragmatic deficits, such as ADHD population ([Cordier et al., 2017](#)).

Even though a replication of this study on a larger sample might further examine and validate the psychometric properties of this tool, the current findings point to the potential impact of this tool in the assessment of the pragmatic profile in the cognitive diagnostics, thus, proposing a novel instrument for the identification and, consequently, explanation of the causes for the social communication difficulties in the individuals' pragmatic disorders. That is, this pragmatic kit may help in diagnosing certain deficits in the pragmatic abilities for the implementation of the intervention programs over time or identification a decline or a marked worsening in the pragmatic abilities in the Hebrew-Speaking ADHD population.

5. Conclusions

The results, presented in this study, determine the impact of different pragmatic processes involved across different types of the pragmatic tasks. The current findings support the separate clustering mode of the

figurative language and humor tasks, which can be related to the different cognitive processes. Another important aspect that should be mentioned is the potential value of APACS as the assessment tool of the pragmatic deficits in the ADHD population. However, the future research on a larger and more heterogeneous sample size might be proposed for a further empirical study of the psychometric diagnostic opportunities of pragmatic deficiencies indicated in the ADHD group. The current research findings raise additional questions for a future research. The first question would be to define how cognitive functions are involved in different pragmatic tasks by completing APACS with other neuropsychological tests. Another question that should be addressed in the future research is whether the pragmatic deficits, described in the ADHD group, can be depicted in other clinical populations, such as ASD, thus, expanding the scope of exploratory studies of this tool on other clinical groups for further investigation of the comorbidity of ADHD disorder in terms of the pragmatic deficits.

The present study has some expected limitations, which suggest directions for the future research. Nevertheless, it has been shown that APACS can promote the inclusion of the pragmatic skills in the diagnostic practice of ADHD. Moreover, it can help not only identify the pragmatic difficulties in the ADHD population but also provide a valid onset criterion for advancing effective intervention programs that are specifically focused on pragmatic skills, thus, helping the individuals with pragmatic disorders to improve their social skills for a more successful integration in their academic studies and at their workplaces.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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