Sleep Medicine 117 (2024) 99–106

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Sleep quality relates to language impairment in children with autism spectrum disorder without intellectual disability

Carmen Berenguer [a], Eva Rosa [b,*], Simona De Stasio [c], Nora Choque Olsson [d]

[a] Department of Developmental and Educational Psychology, ERI-Lectura Faculty of Psychology and Speech Therapy University of Valencia, Blasco Ibanez, 21, 46010, Valencia, Spain
[b] Department of Basic Psychology, ERI-Lectura, Faculty of Psychology and Speech Therapy, University of Valencia, Blasco Ibanez, 21, 46010, Valencia, Spain
[c] Department of Human Studies, LUMSA University, Piazza Delle Vaschette, 101, 00193, Rome, Italy
[d] Department of Psychology, Stockholm University, 106 91, Stockholm, Sweden

ARTICLE INFO

Keywords:
Autism spectrum disorder
Children
Sleep quality
Language impairment
Structural language
Pragmatic language
Communication skills
Cluster analysis

ABSTRACT

Objectives: This study aimed to identify sleep quality profiles of children with autism spectrum disorder (ASD), to compare these profiles with those of typically developing (TD) children, and to verify whether there are differences between them in terms of language skills.

Methods: We evaluated the sleep quality and language skills of 47 children with ASD without intellectual disability (ID) and 32 children with TD. Using a hierarchical cluster analysis, we identified two sleep quality ASD profiles (poor and good). We then performed a series of MANCOVAs and ANOVAs to compare the sleep quality and language skills of the two ASD clusters and the TD group.

Results: A main group effect (TD, "poor" cluster, and "good" cluster) was found in the total sleep quality and all its dimensions. Significant differences were revealed between the "good" and "poor" clusters in the total structural language score ($F1,46 = 10.75$, $p < 0.001$) and three of its subscales (speech: $F1,46 = 9.19$, $p < 0.001$; syntax, $F1,46 = 8.61$, $p = 0.001$; coherence: $F1,46 = 11.36$, $p < 0.001$); the total pragmatic language score ($F1,46 = 7.00$, $p = 0.001$) and three of its subscales (inappropriate initiation: $F1,46 = 8.02$, $p = 0.001$; use of context: $F1,46 = 8.07$, $p = 0.001$; nonverbal communication: $F1,46 = 7.35$, $p = 0.001$); and the social relations score ($F1,46 = 9.97$, $p = 0.003$).

Conclusions: Sleep quality in children with ASD (especially a subgroup) is worse than in children with TD. There is an association between sleep quality and language skills, both at the pragmatic and structural levels.

1. Introduction

Autism spectrum disorder (ASD) is a complex neurodevelopmental condition characterized by clinically significant impairment in the social communication and interaction domains, as well as restricted, and repetitive behavioral patterns and interests (DSM-V [1]). In addition to core symptoms, a wide range of comorbid conditions are present in 95% of children with ASD [2,3]. The increasing prevalence of ASD over the last decades (between 1/34 and 1/76 according to Ref. [4]; 1/54 according to Ref. [5]; 1/71 according to Ref. [6]), makes it necessary a careful scientific evaluation of the relationship between core ASD impairments and the wide variety of co-occuring conditions [7].

Two of the most common ASD co-occurring conditions are: sleep disturbances [2,8,9] and specific language impairments, other than the symptoms considered central to the diagnosis of the disorder [10–13]. In children with ASD, impairments in social interactions, based on the difficulty in interpreting the thinking of the interlocutor, converge with difficulties in the pragmatic component of language, i.e., in the effective use of language for acts of communication. Although structural language difficulties (form and semantics) are not considered central features of the disorder they often appear as co-occurring symptoms. Language impairments are often accompanied by intellectual disability, although the level of severity vary widely across individuals meeting diagnostic criteria for ASD. Some individuals are nonverbal with severe intellectual disability, while others have mild language impairment and mild intellectual disability. Language impairment can also co-occur with ASD

* Corresponding author.
E-mail addresses: carmen.berenguer@uv.es (C. Berenguer), eva.rosa@uv.es (E. Rosa), s.destasio@lumsa.it (S. De Stasio), nora.choque-olsson@psychology.su.se (N. Choque Olsson).

https://doi.org/10.1016/j.sleep.2024.03.028
Received 12 September 2023; Received in revised form 11 March 2024; Accepted 16 March 2024
Available online 18 March 2024
1389-9457/

independently of intellectual disability (ID), measured as intelligence quotient (IQ). Indeed, some individuals with ASD, without intellectual disability, still show language impairments and poor performance in various cognitive processes that could be related to other comorbid conditions as sleep problems.

1.1. Sleep problems in ASD

Over the past two decades, interest in the study of sleep disorders in children with neurodevelopmental disorders, specifically ASD, has increased as a result of the awareness of their critical impact on the daily life and wellbeing of children and their families. Research on ASD and sleep covers different aspects such as: the prevalence and types of sleep problems; the coexistence and relationships with other impairments; the impact on the quality of life of individuals with ASD and their caregivers; and the efficacy of the different types of treatment available [9].

Regarding the prevalence and types of sleep problems, several studies have shown that children and adolescents with ASD present higher rates and greater complexity than children and adolescents with typical development (TD; 50%–80% versus 35%–46% according to Ref. [9]). A recent systematic review [14] of case-control studies, that considered both objective parameters from sleep EEG and polysomnography, and subjective parameters from sleep questionnaires, concluded that children and adolescents with ASD experience a higher rate of both qualitative and quantitative sleep disturbances than children and adolescents with TD. The objective measures showed that ASD children have greater difficulties in initiating and maintaining sleep than TD children: shorter total sleep time (TST), higher sleep latency (SL) and higher number of wakefulness after sleep onset (WASO). These results were consistent with subjective parental reporting of higher bedtime resistance, higher sleep onset delay and higher night waking activities. Many other studies demonstrate that the sleep disturbances most commonly experienced by children with ASD include trouble for setting the time to go sleep (bedtime resistance), and for falling asleep (delayed sleep latency), as well as reduced sleep efficiency, mainly due to night awakenings, parasomnias, sleep-disordered breathing and sleep wake transition disorders [15–17].

According to previous literature there are connections between decreased sleep quality and/or sleep deprivation, and a general intensification of ASD symptoms [18–21], especially communication problems [22–25]. Moreover, improving sleep has been found to have beneficial effects in ameliorating stereotyped and rigid behaviors [26, 27]. As sleep is a behavioral and emotional regulator, poor sleep quality also can worsen other internalizing and externalizing problems of children with ASD such as anxiety and mood symptoms [28–30], negative affect and challenging behaviors [31,32], irritability, aggression, and self-injury [32–34]. In turn, emotional dysregulation and behavioral maladjustments hinder communication with parents and lead to poor sleep hygiene, which according to McLay et al. [35] perpetuates sleep problems in children with ASD. It is also well established that co-occurring sleep problems in ASD endure from childhood to adolescence playing a negative role in synaptic plasticity during development, which is critical for daytime cognitive and adaptative functioning [36]. Altogether, available evidence suggests that the relationship between sleep and autism symptoms is bidirectional [37,38].

1.2. Language impairment in ASD

Children and adolescents with ASD often show language impairments, coexisting with social communication problems which is a core symptom of this neurodevelopmental disorder [11]. Language is supported by different structural and pragmatic skills. Structure refers to form (e.g., phonology, morphology, syntax) and content (semantics), whereas pragmatics has to do with the appropriate use of language in social or situational contexts. There is great variability among individuals with ASD in terms of the type and severity of language impairments, depending on variables such as age, intellectual level or other coexisting development problems [39,40]. Indeed, the linguistic profile of ASD varies significantly as they get older. In the preschool stage children with ASD show difficulties in pragmatic and structural language, like children with specific language disorder, which could lead to a misdiagnosis [41]. When they reach the school stage the structural deficiencies improve, relative to other language impairments, while the pragmatic ones acquire more prominence [42]. In recent years, copious studies have been published on pragmatic language impairments, which are considered a universal feature of ASD. However, research on structural language has received little attention despite the fact that it is also commonly affected in ASDs. Pragmatic language has been linked to social skills [43] to explain the foundations of effective social communication. Interestingly, there is also evidence that pragmatic competence can be predicted using theory of mind (ToM), working memory, and structural language [10,13]. Consistently, some studies suggest that there is a link between structural language deficits and social skills in ASD that is mediated by reduced pragmatic competence [39,43]. Therefore, when approaching the study of language impairments in ASD, it is essential to take into account the relationship between pragmatic and structural aspects, as well as the relationship with other skills and coexisting problems. In the next section we will take a closer look at the relationship between sleep quality and language skills in children with ASD.

1.3. The relationship between sleep and language in ASD

As stated above, sleep problems and language impairments are two of the most common coexisting conditions on ASD. On the one hand, children with ASD can show language difficulties independently of intellectual disability. On the other hand, poor sleep quality is a good predictor of various behavioral, emotional, and cognitive problems. However, the association between sleep quality and language impairment in children with ASD without ID is poorly understood and further evidence is needed in this regard.

Several studies using experimental and survey-based methodology have shown the crucial role of sleep for phoneme recognition, vocabulary retention, and semantic knowledge in general population (e.g. Ref. [44]) and ASD [45,46]. Thereby, sleep quality can be a risk predictor for developmental delays and impairments in language acquisition and use. This idea is supported by a longitudinal study recently published [8] which compared the developmental trajectories of children with ASD with and without sleep problems. More than a thousand participants were assessed once every three months for three years. The results showed that participants without sleep problems developed faster compared to participants with sleep problems in all measured indicators, including receptive and expressive language. Similarly, Knowland et al. [47] analysed parent-reported day-time and night-time sleep duration of 354 children over five time points between 6 and 36 months-of-age. The sample included participants of relatively low socioeconomic status (SES), of various ethnicities, with and without neurodevelopmental disorders. They found that more night-time sleep relative to day-time sleep predicted better receptive vocabulary at age five.

1.4. Current study

The findings presented in the previous section on the relationship between sleep quality and language skills come from highly diverse samples in terms of age and developmental characteristics Furthermore, sleep quality research is characterized by considerable variability in terms of methodology rigor and mixed results in the literature. It is likely that the divergent results found in different research can be explained, at least in part, by the use of different evaluation measures, as well as by the diversity of sleep problems and cognitive levels studied. Therefore, measures of sleep quality, along with different types of sleep problems and cognitive levels, should be taken into account to identify more homogeneous profiles. A cluster analysis may be an appropriate methodology to establish different profiles of sleep quality within ASD when attempting to analyze the relationships between sleep problems and other common difficulties in this disorder, such as language and communication skills.

The present study is an attempt to shed light on the role of sleep quality in the structural and pragmatic language skills of children with ASD without intellectual disability. Specifically, it was designed to address the following objectives: 1) To identify profiles of children with ASD without ID, based on their parents' report sleep quality, and to compare these profiles with TD children. Consistent with previous literature, this study hypothesizes that children with ASD will have a lower sleep quality than the TD group.

2) To explore the differences in language skills among the identified profiles, which constitutes the most relevant contribution of this study. Given the important role that sleep has for the development of cognitive processes involved in language and communication skills, we expect that the profile with lower sleep quality will show more impairments not only in the pragmatic language skills but also in the structural ones.

2. Method

2.1. Participants

Participants were 47 children with ASD without ID and 32 TD children between 8 and 12 years old (see Table 1).

This study was conducted using a non-probabilistic convenience sampling. The clinical sample was recruited from clinical health centers. The clinical diagnosis was established based on the Diagnostic and Statistical Manual of Mental Disorders- Fifth Edition, DSM-5 [1], the Autistic Diagnostic Interview—Revised (ADI-R [48]), and/or the Autism Diagnostic Observation Schedule-WPS (ADOS-WPS [49]). Both measures were administered to parents and children by two psychologists certified in these tests. The Social Communication Questionnaire (SCQ [50]) was administered, considering the recommended cut-off points.

The children with TD were recruited throughout public schools that agreed to participate in the present study. None of them presented a history of psychopathologies or criteria for ASD or ADHD diagnosis according to DSM-5 and none of them were taking any psychoactive medication. The exclusion criteria for all groups were: having an IQ less than 80, having motor or sensorial deficits, and having mental or neurological diseases.

2.2. Measures

2.2.1. The Sleep Disturbance Scale for Children

(SDSC [51]; is a 26-item parent-reported questionnaire that assesses the occurrence of sleep disturbances during the last 6 months in children aged 6–16 years. The 26 items are rated on a 5-point scale (never to always), yielding a continuous variable ranging from 26 to 130 with higher values reflecting a greater severity of symptoms. The first two questions measure the total sleep time and latency to sleep onset. The remaining items, assess the frequency of sleep-related behaviors between conditions on six subscales: disorders of initiating and maintaining sleep (DIMS); sleep breathing disorders (SBD); disorders of arousal (sleepwalking, sleep terrors) (DA); sleep–wake transition disorders (SWTD); disorders of excessive somnolence (DOES); and sleep hyperhidrosis (falling asleep sweating and night sweating) (SHY). A total sleep disturbances score was obtained by summing all subscale scores. The internal consistency was $\alpha = 0.79$ and test–retest reliability $r = 0.71$ over a 6-month interval [51]. For this study we use the Spanish version form Pagerols et al. [52] with good internal consistency (0.82).

Table 1
Mean and standard deviation of the raw scores on sociodemographic characteristics.

	TD (n = 32) Mean (SD)	ASD (n = 47) Mean (SD)	$t_{(78)}$	χ^2	p
Age (years)	8.75 (1.22)	9.37 (1.75)	1.56	–	0.011
IQ	100.4 (8.22)	98.37 (10.92)	0.93	–	0.109
Sex (% boys)	65.6%	89.3%		6.64	0.010*
P. Education	3.27 (0.95)	3.05 (1.09)	0.57	–	0.561
Medication (% yes)	0.0%	41.7%			
Sleep problems	31.78 (4.07)	49.40 (3.81)	−6.44		<0.01*
Vocabulary level	13.02 (2.75)	11.89 (3.24)	−1.02		0.280
ADI-R	–	28.3 (5.7)			
SCQ	2.9 (2.5)	21.7 (6.3)	16.03		<0.01*

Note. P. Education (Parental education), SCQ (Social Communication Questionnaire)*$p < 0.05$.

2.2.2. The Children's Communication Checklist

(CCC-2 [53]) provides information about communication characteristics in subjects from 4 to 11 years old. The frequency of the behaviors described in each item included in the CCC-2 is rated on a 4-point scale; a high score indicates greater communication problems. In addition, the 70 items included in the CCC-2 are grouped in 10 subscales that measure different communicative aspects: four scales assess the structure of the language (speech, syntax, semantics, coherence), four scales assess pragmatic language (inappropriate initiation, stereotyped language, the use of context, and non-verbal communication), and two scales assess the behaviors that are affected in children with ASD (social relationships and interests).

Internal consistency reliability coefficients for the CCC-2 range from 0.77 to 0.85 for all subscales across age groups [53] The scales also have good reliability in the sample of the present study (Cronbach's alpha: 0.932). This specific grouping, although not contemplated in the CCC-2, has been used in other previous studies [54].

2.2.3. The Clinical Evaluation of Language Function, 5th edition observation rating scale [CELF-5 ORS]

[55]. The CELF is an individually administered assessment tool designed for the diagnosis and evaluation of language and communication disorders in individuals 5–21 years of age. The measure is often used for the purpose of identifying and detailing the nature of language problems, determining eligibility for special education services. The CELF-5 proposes a stepwise evaluation process that reflects best practices in education for identifying struggling students as well as potential classroom supports. The suggested process begins with the Observational Rating Scale (ORS), which guides the observation of naturalistic speech, language, and communication behaviors. The ORS was used in the present study. Specifically, the ORS is comprised of a total of 40 descriptive statements reported by parents or teachers to rate children communication behavior, that are categorized into four general areas as follows: listening, speaking, reading, and writing. The respondent is asked to rate each of the statements by indicating the frequency of the problem (never 0, sometimes 1, often 3, and always 4). Therefore, the higher the total score, the more language and communication are affected. For the present investigation only parent ratings of the ORS were collected. Research has shown good validity and reliability for both the ORS [56]. Alphas for parent report by category ranged from 0.86 (Listening), to 0.95 (Writing), indicating good to excellent internal consistency for each category.

2.3. Procedure

The present study follows the statements of the Ethics Committee of the Universitat de València (UV-INV_ETICA-1905517). The parents provided their oral and written informed consent. The evaluation was carried out in a room of the Faculty of Psychology. All the measures were administered to parents and children by two trained psychologists. The parents (mostly mothers) provided information about their children's language and communication skills, ASD symptoms, and sleep quality.

2.4. Data analysis

The statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS v 26.0. IBM, Barcelona, Spain 2012). First, all the data were checked for multicollinearity and multivariate outliers. The asymmetry and kurtosis data indicate that most of the variables followed a normal distribution (all values between −1 and 1). Variables that did not show a normal distribution were transformed using square-root transformation. To explore distinct profiles (i.e., subgroups) of sleep quality in ASD, and TD groups we performed hierarchical cluster analysis. The input for this analysis included the different domains of the sleep quality.

We evaluated hierarchical clustering using multiple internal validity measures. Specifically, we varied the number of clusters from two to three, and the optimal *N*-cluster solution was determined based on visual inspection of the dendrogram figure and the agglomeration coefficients. Additionally, we also carried out the same procedure with non-hierarchical clustering, namely, K-means, because this procedure allows us to specify the number of clusters in advance. Lastly, to fit the optimal cluster analysis solution, we used the variance ratio criterion (VRC) for each selected cluster. The VRC refers to the ratio of the 'within variance' (variance explained by the typology) and 'between variance', corrected for the number of clusters and responses. The two-cluster solution seemed to be optimal in the hierarchical cluster analysis, based on Ward's method, and the VRC showed a lower score for two solutions [57].

After analyzing the resulting dendrogram and data, the decision was made to group the children with autism in two clusters, controlling for medication (MANCOVAs). Cluster solutions were interpreted as poor and good sleep quality. Then, we checked the possible differences between the Clusters obtained and a control group with TD. The main advantages of cluster-level strategy in exploratory data analysis are their simplicity and applicability to different types of outcomes [58].

Finally, one-way analyses of variance (ANOVAs) were conducted to determine the differences between the children in the cluster groups on language and communication skills measures; the Children's Communication Checklist –CCC–2 (speech, syntax, semantics, coherence, inappropriate initiation, stereotyped language, the use of context, and non-verbal communication, social relationships, interests, structural language, and pragmatic language) and the CELF- ORS (total score). The proportion of total variance accounted for by the independent variables was calculated using partial eta squared (according to Ref. [59]: eta squared, 0.06 = small; 0.06–0.14 = medium, 0.14 = large).

Open practice statement: The dataset is openly available at https://zenodo.org/records/10840174?preview=1

3. Results

3.1. Demographic information

The results of demographics revealed that the mean age of the group with autism was 8.75, SD (1.22) and that of the TD group was 9.37, SD (1.75). There were no statistical differences between both groups on IQ (measured by the K-BIT [60]), age, and their level on a Vocabulary subtest from the WISC-IV [61] [t (78) = −1.02 p = .28]. Moreover, 21 of the participants in TD group and 42 in the ASD group were boys. The prevalence of sleep problems in the participants was: TD (n = 7, 21,8%), ASD (n = 32, 68,1%; see Table 1).

3.2. Profiles of sleep quality in children with ASD without ID comparison of profiles with TD

The first goal of the analysis was to examine whether children with ASD were more likely to cluster into a single group or multiple groups on the basis of measures of sleep quality, and to compare their sleep quality with the TD group.

Results from the hierarchical cluster analysis with the children's sleep quality determined an optimal number of clusters in two groupings, distinguished by the tendency of their scores on the variables included in the analysis: DIMS, SBD, DA, SWTD, DOES, SHY, and total sleep quality. Cluster 1 (n = 24; 51.06%) presented good scores of sleep quality. By contrast, Cluster 2 (n = 23; 48.93%) showed poor scores than Cluster 1 on all the sleep quality dimensions measured.

A Multivariate Analysis of Covariance (MANCOVA) controlling for medication was conducted to determine the significant differences between the two clusters in the sleep quality dimensions considered and TD group. Based on the described patterns of sleep quality dimensions, Cluster 1 was labeled "good", and Cluster 2 was called the "poor" group (see Table 2). The scatterplot (Fig. 1) helped us visualize how sets of data are related. REGR scores represent the coefficient of regression equation for each cluster.

The MANCOVA conducted to assess the main group effect among the three groups was statistically significant [Wilk's Lambda (Λ) = 0.117, $F_{(14,140)} = 19.74$, $p < 0.001$, $\eta^2 p = 0.66$]. ANCOVAs showed statistically significant differences on all dimension of sleep quality: DIMS, $F_{2,\,76} = 52.26$, $p < 0.001$, $\eta_p^2 = 0.58$; SBD, $F_{2,\,76} = 7.81$, $p < 0.001$, $\eta_p^2 = 0.17$; DA, $F_{2,\,76} = 36.98$, $p < 0.001$, $\eta_p^2 = 0.49$; SWTD, $F_{2,\,76} = 19.83$, $p < 0.001$, $\eta_p^2 = 0.34$; DOES, $F_{2,\,76} = 15.05$, $p < 0.001$, $\eta_p^2 = 0.28$ and SHY, $F_{2,\,76} = 5.84$, $p = 0.004$, $\eta_p^2 = 0.13$.

Statistically significant differences were also found on the total sleep quality, $F_{2,\,76} = 229.09$, $p < 0.001$, $\eta_p^2 = 0.85$ (Table 2).

Tukey post-hoc analyses showed statistically significant differences between the three groups on DIMS dimension and the Total score of sleep quality. Therefore, there were statistically significant differences between Cluster 1 "good" and Cluster 2 "poor" and between the two cluster of sleep quality in children with ASD and the TD group.

A similar pattern was observed in the other dimensions of sleep quality. Specifically, there were significant differences between Cluster 1 "good" and Cluster 2 "poor" in all sleep quality dimensions, and there were significant differences between Cluster 2 "poor" and TD group in all sleep quality dimensions. In contrast, the Cluster 1 "good", in comparison with the TD group, did not reveal statistically significant differences in the sleep quality dimension of sleep breathing, disorders of arousal, sleep-wake transitions, somnolence and hyperhidrosis. Fig. 2 shows the comparisons of the mean scores of the two ASD clusters and the TD group.

3.3. Differences in language and communication skills across the profiles of children with ASD

Table 3 presents the comparison of two Clusters of ASD, Cluster 1 "good" and Cluster 2 "poor", on language and communication abilities. The analysis of variance revealed statistically significant differences between the two clusters in three scales of structural language after applying Bonferroni correction (<0.003): Speech: $F_{1,46} = 9.19$, $p < 0.001$, $\eta_p^2 = 0.35$; Syntax, $F_{1,46} = 8.61$, $p = 0.001$, $\eta_p^2 = 0.34$; Coherence: $F_{1,46} = 11.36$, $p < 0.001$, $\eta_p^2 = 0.38$; and the total structural language score: $F_{1,46} = 10.75$, $p < 0.001$, $\eta_p^2 = 0.37$.

Similarly, the pragmatic scales that remained significant between the two Clusters were: Inappropriate initiation: $F_{1,46} = 8.02$, $p = 0.001$, $\eta_p^2 = 0.33$; use of context: $F_{1,46} = 8.07$, $p = 0.001$, $\eta_p^2 = 0.33$; nonverbal communication: $F_{1,46} = 7.35$, $p = 0.001$, $\eta_p^2 = 0.32$ and the pragmatic language total score: $F_{1,46} = 7.00$, $p = 0.001$, $\eta_p^2 = 0.31$.

Moreover, Social relations scale showed statistically significant differences between the two clusters: $F_{1,46} = 9.97$, $p = 0.003$, $\eta_p^2 = 0.17$. However, there were not significant differences between Cluster 1 "good" and Cluster 2 "poor" in the CELF-ORS (Table 3).

Table 2
Mean of Sleep Quality according to Cluster membership.

Measure	Cluster 1 Good (n = 24) M SD		Cluster 2 Poor (n = 23) M SD		TD (n = 32) M SD		$F_{(2,76)}$	p	η^2_p	TukeyPostHoc
DIMS	11.63	4.37	17.70	5.12	6.78	2.15	52.26	0.001*	0.58	CL2>CL1>TD
SBD	3.83	1.24	4.96	1.99	3.5	0.84	7.81	0.001*	0.17	CL2>CL1, TD
DA	4.04	1.68	6.91	2.19	3.28	0.81	36.98	0.001*	0.49	CL2>CL1, TD
SWTD	10.13	4.05	13.91	3.98	8.06	2.26	19.83	0.001*	0.34	CL2>CL1, TD
DOES	7.50	2.83	11.52	3.45	7.03	3.21	15.05	0.001*	0.28	CL2>CL1, TD
SHY	2.88	1.30	4.39	1.99	3.13	1.60	5.84	0.004*	0.13	CL2>CL1, TD
T. Sleep q	41.96	8.10	76.61	10.96	31.78	4.07	229.09	0.001*	0.85	CL2>CL1>TD

Note. DIMS (Disorders of initiating and maintaining sleep), SBD (sleep breathing disorders), DA (disorders of arousal), SWTD (sleep-wake transition disorders), DOES (disorders of excessive somnolence), SHY (sleep hyperhidrosis), T. Sleep q (total sleep quality) *p < .05.

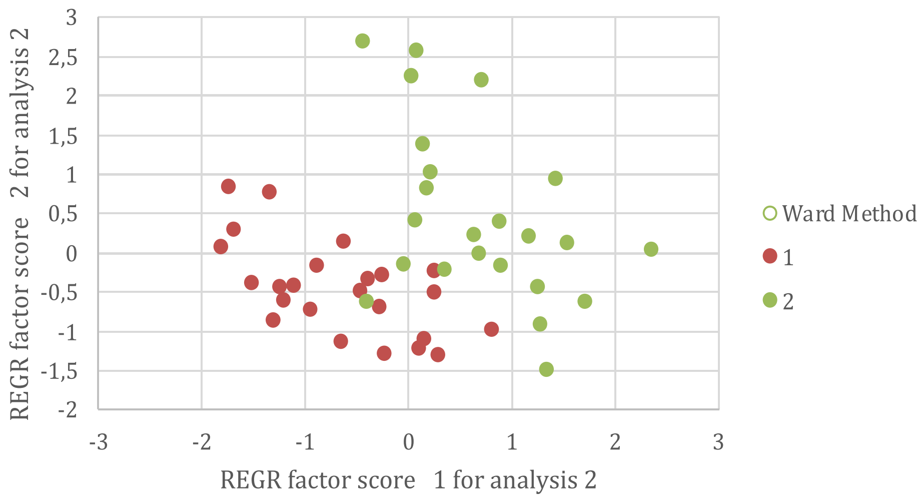

Fig. 1. Scatterplot of pairwise comparisons between clusters on Sleep quality subscales in ASD group.

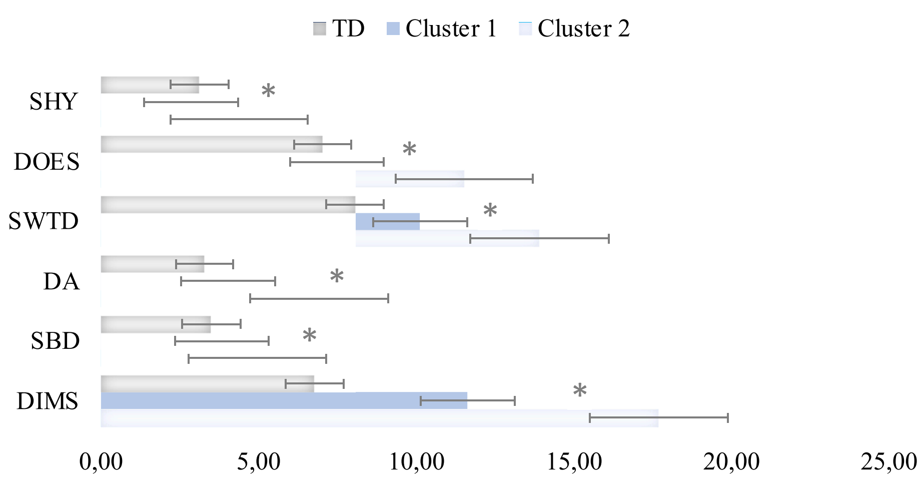

Fig. 2. Means of the clusters 1, 2 and TD on children sleep quality parents' report.

4. Discussion

The aims of the present study were to identify sleep quality profiles of children with ASD without ID, to compare these profiles with those of TD children, and to verify if there are differences between the identified clusters in terms of language skills. To this end, we evaluated the sleep quality and language skills of 47 children with ASD without ID and 32 children with TD, between 8 and 12 years old. Two sleep quality profiles (poor and good) were identified within the group of participants with ASD. A main group effect (TD, "poor" cluster, and "good" cluster) was found in the total sleep quality and all its dimensions. Pairwise comparisons revealed significant differences between the two cluster of the ASD group (good and poor) as well as between these both clusters and the TD group, in the total score and the DIMS dimension of the SDSC [51]. For the rest of the sleep quality dimensions (SBD, DA, SWTD, DOES, SHY), significant differences were found between the two clusters of the ASD group, as well as between the poor sleep quality cluster and the TD group, but not between the good sleep quality cluster and the TD group. In summary, the sleep quality of children with ASD was worse than that of children with TD, and among children with ASD a subgroup with especially poor sleep quality was clearly distinguished. Regarding language measures, significant differences were revealed between the "good" and "poor" clusters in the total structural language score and three of its subscales (speech, syntax, coherence), the total pragmatic

Table 3
Mean of language and communication skills in children with ASD according to Cluster attribution (good/poor sleep quality).

	Cluster 1 Good		Cluster 2 Poor (n = 23)		$F_{(1, 46)}$	*p*	η^2p
	M	SD	M	SD			
Speech	3.96	5.03	8.22	4.58	9.19	0.00*	0.35
Syntax	4.88	5.02	8.87	4.26	8.61	0.01*	0.34
Semantics	6.54	4.76	9.43	3.69	5.38	0.03	0.28
Coherence	8.63	4.55	12.65	3.56	11.36	0.00*	0.38
Inappropriate I.	10.75	4.64	13.87	2.58	8.02	0.01*	0.33
Stereotyped L.	7.42	4.00	10.09	4.03	5.19	0.03	0.28
Use of context	10.13	4.39	13.22	2.89	8.07	0.01*	0.33
Nonverbal C.	9.33	4.99	12.48	2.50	7.35	0.01*	0.32
Social relations	8.67	4.87	11.78	2.92	7.00	0.01*	0.31
Interests	11.46	4.63	13.22	3.74	2.04	0.16	0.19
Structural L	24.00	17.7	39.17	13.63	10.75	0.00*	0.37
Pragmatic L	37.63	14.9	49.65	8.16	11.61	0.00*	0.40
CELF-ORS	55.88	12.5	58.70	14.61	0.51	0.48	0.13

Note. CELF-ORS (Clinical Evaluation of Language Function - Observational Rating Scale), Stereotyp L (Stereotyped language) Inappropriate I. (inappropriate initiation), Stereotyped L. (stereotyped language), Nonverbal C. (nonverbal communication), Structural L (language), M (Mean), SD (standard deviation).
*$p < 0.003$ (Bonferroni correction).

language score and three of its subscales (inappropriate initiation, use of context, and nonverbal communication), and the social relations score.

As discussed above, decreased sleep quality and/or sleep deprivation has been repeatedly associated with a deterioration of core ASD symptoms, prominent among which are communication problems [22–25]. Specifically, poor sleep quality has been linked with difficulties in expressive, receptive, and social language [62]. In addition, several studies have shown the essential role of sleep for language learning and consolidation [44,63–66]; and have identified poor sleep quality as a risk predictor for developmental delays and impairments in language acquisition [8,41,47]. Taken together, the findings of the current study provide additional empirical support for the association between sleep quality and language skills, both at a pragmatic and structural level. Our results should be interpreted taking into account that we have used a cross-sectional design, and therefore it is not possible to establish causal relationships. In addition, we can reach conclusions about the relationship between sleep quality and language use, but not between sleep quality and language development. Likewise, the possible causality of these relationships must be interpreted with caution given that a non-experimental methodology has been used. Indeed, previous literature suggests a complex relationship between sleep problems and autism symptoms [37,38]. For example, behavioral maladjustments can hinder communication with parents and lead to poor sleep hygiene, which in turn can perpetuate sleep problems in children with ASD [35]. Regarding the specific mechanisms underlying the relationship between sleep quality and language we can consider different alternatives. On the one hand, it is reasonable to assume that children with impaired language have more difficulty conveying their needs and discomfort at bedtime, leading to a poorer sleep quality. On the other hand, it is known that poor sleep quality affects brain areas involved in executive functioning, learning skills, sustained attention, working memory and cognitive procedural memory. The deterioration of these cognitive functions also plays a role in language skills that could be mediated by sleep problems. For example, Tesfaye et al. [67] found that the quantity and quality of sleep were related to the executive function involved in the behavioral regulation of ASDs, which in turn is related to difficulties at the pragmatic level [68]. Similarly, Calhoun et al. [69] reported that working memory correlated significantly with expressive language and language comprehension in a group of adolescents with clinically elevated sleep disturbances. Future research should analyze the possible mediating or modulating role of sleep quality in the relationship between cognitive processes, such as executive functioning and working memory, and language impairment at both a pragmatic and structural level. Consequently, if direct or indirect associations exist between sleep problems and language development, early intervention to prevent poor language development should promote sleep quality. In this regard, various therapies have been proposed to improve sleep in children with ASD, some of which such as melatonin, behavioral interventions, and educational programs have proven to be effective in improving multiple domains of sleep problems (see also [70], for a practice guideline to the treatment of sleep problems in ASD.). Recently, incipient evidence has also been obtained on the feasibility and effectiveness of cognitive-behavioral therapy (CBT) for the treatment of insomnia in children and adolescents with ASD. A pilot study involving 17 school-aged children with autism and insomnia showed significant improvements in objective and subjective measures of sleep quality, as well as other symptoms (irritability, lethargy, stereotypy, and hyperactivity), after a CBT intervention of 8 sessions [71]. In another recent study [72], six adolescents with ASD followed an internet-delivered CBT treatment for insomnia. Both quantitative and qualitative results showed that the participants were satisfied with the intervention, had improved their knowledge about their sleep patterns, and had reduced their symptoms of insomnia.

This study is not without limitations. First, the small sample size and the sampling method may compromise the generalizability of the results. Secondly, most of our informants were mothers, so it would be necessary to also include the perceptions of fathers or siblings in order to have a more global vision of sleep problems and their impact on language. The next step in this line of research should be aimed at generalizing the results of the pilot studies through a randomized controlled trial study, to verify the impact of different types of intervention, not only on the symptoms of insomnia and the quality of life, but also about the different variables of language. This will allow us to delve deeper into the causal relationships between sleep quality and language. Another issue to consider for future research is the inclusion of objective measures of sleep along with the parent report. In the present study we used the Sleep Disturbance Scale for Children (SDSC [51]) in which parents are asked to estimate the frequency of different sleep-related disorders. Future studies should comprehensively explore this construct, and accurately address the measurement of all its dimensions, using objective indicators such as actigraphy or polysomnography.

Finally, the present study also has important clinical implications. Difficulties in language development are associated with poor academic performance and negative long-term outcomes, in work, educational, and social settings [73]. Children with ASD often has marked language difficulties that compromise their opportunities in different areas of life. On the other hand, children with ASD have a higher prevalence of sleep problems than children with TD, which worsens their quality of life and that of their family. Furthermore, the results of the present study show a relationship between these two problems that frequently coexist with the core symptoms of ASD. Therefore, when evaluating the symptoms associated with ASD, it is necessary to consider sleep problems and their direct or indirect repercussions on language skills. Research on the causes and possible treatments for sleep problems in ASD is promising but still nascent. Future research should test the effectiveness of treatments, such as those based on CBT, not only on the quality of life of individuals with ASD and their families, but also on different cognitive processes. It is essential to examine if promotion of sleep quality enhance language development and use, both in a direct manner or through the improvement of other cognitive processes such as working memory or executive functioning.

5. Conclusion

Our results show that the sleep quality of children with ASD is worse than that of children with TD, and that there is an association between sleep quality and language skills, both at the pragmatic and structural levels. These results have several implications: i) the importance of taking sleep problems into account when evaluating symptoms associated with ASD; ii) the need to further examine the direct and indirect relationships of sleep quality with language; iii) the need to test the effectiveness of treatments to improve sleep quality, such as those based on CBT, on quality of life and language.

Funding

The project was granted by the Ministerio de Ciencia e Innovación (Ministry of Science and Innovation) and the reference is: PID2021-128044NA-100. Grant funds from: "Agencia Estatal de Investigación (AEI)", Spain, and "Fondo Europeo de Desarrollo Regional de la Union Europea (FEDER, UE).

CRediT authorship contribution statement

Carmen Berenguer: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Eva Rosa:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Simona De Stasio:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis. **Nora Choque Olsson:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Carmen Berenguer reports financial support was provided by Ministerio de Ciencia e Innovación, Spain.

Acknowledgements

The authors also wish to thank the UEO València and UEO Dènia (Conselleria de Educacion Generalitat Valenciana) and the families who participated in this study.

References

[1] American Psychiatric Association, DSM-5 Task Force. Diagnostic and statistical manual of mental disorders: DSM-5™. fifth ed. American Psychiatric Publishing, Inc; 2013. https://doi.org/10.1176/appi.books.9780890425596.
[2] Cohen S, Conduit R, Lockley SW, Rajaratnam SMW, Cornish KM. The relationship between sleep and behaviour in autism spectrum disorder (ASD): a review. J Neurodev Disord 2014;6:44. https://doi.org/10.1186/1866-1955-6-44.
[3] Soke GN, Maenner MJ, Christensen D, Kurzius-Spencer M, Schieve LA. Prevalence of Co-occurring medical and behavioral conditions/symptoms among 4- and 8-year-old children with autism spectrum disorder in selected areas of the United States in 2010. J Autism Dev Disord 2018;48(8):2663–76. https://doi.org/10.1007/s10803-018-3521-1.
[4] Baio J, Wiggins L, Christensen DL, Maenner MJ, Daniels J, Warren Z, Kurzius-Spencer M, Zahorodny W, Robinson Rosenberg C, White T, Durkin MS, Imm P, Nikolaou L, Yeargin-Allsopp M, Lee LC, Harrington R, Lopez M, Fitzgerald RT, Hewitt A, Pettygrove S, Constantino JN, Vehorn A, Shenouda J, Hall-Lande J, Braum KN, Dowling NF. Prevalence of autism spectrum disorder among children aged 8 Years - autism and developmental disabilities monitoring network, 11 sites, United States, 2014. Morbidity and mortality weekly report. Surveillance summaries (Washington, D.C.: 2002) 2018;67(6):1–23. https://doi.org/10.15585/mmwr.ss6706a1.
[5] Maenner MJ, Shaw KA, Baio J, EdSl, Washington A, Patrick M, DiRienzo M, Christensen DL, Wiggins LD, Pettygrove S, Andrews JG, Lopez M, Hudson A, Baroud T, Schwenk Y, White T, Rosenberg CR, Lee LC, Harrington RA, Huston M, Dietz PM. Prevalence of autism spectrum disorder among children aged 8 Years - autism and developmental disabilities monitoring network, 11 sites, United States, 2016. Morb Mortal Wkly Rep - Surveillance Summ 2020;69(4):1–12. https://doi.org/10.15585/mmwr.ss6904a1.
[6] Shaw KA, Williams S, Hughes MM, Warren Z, Bakian AV, Durkin MS, Maenner MJ. Statewide county-level autism spectrum disorder prevalence estimates—seven US states, 2018. Ann Epidemiol 2023;79:39–43.
[7] Hoefman R, Payakachat N, van Exel J, Kuhlthau K, Kovacs E, Pyne J, Tilford JM. Caring for a child with autism spectrum disorder and parents' quality of life: application of the CarerQol. J Autism Dev Disord 2014;44(8):1933–45. https://doi:10.1007/s10803-014-2066-1.
[8] Levin J, Khokhlovich E, Vyshedskiy A. Sleep problems effect on developmental trajectories in children with autism. medRxiv 2022;2022–03. https://doi.org/10.1101/2022.03.30.22273178.
[9] Schwichtenberg AJ, Janis A, Lindsay A, Desai H, Sahu A, Kellerman A, Chong LP, Abel EA, Kinkus JK. Sleep in children with autism spectrum disorder: a narrative review and systematic update. Current Sleep Medicine Reports 2022;8(1):51–61. https://doi.org/10.1007/s40675-022-00234-5.
[10] Baixauli-Fortea I, Miranda Casas A, Berenguer-Forner C, Colomer-Diago C, Roselló-Miranda B. Pragmatic competence of children with autism spectrum disorder. Impact of theory of mind, verbal working memory, ADHD symptoms, and structural language. Applied neuropsychology. Child 2019;8(2):101–12. https://doi.org/10.1080/21622965.2017.1392861.
[11] Happé F, Frith U. Annual Research Review: looking back to look forward - changes in the concept of autism and implications for future research. JCPP (J Child Psychol Psychiatry) 2020;61(3):218–32. https://doi.org/10.1111/jcpp.13176.
[12] Marini A, Ozbič M, Magni R, Valeri G. Toward a definition of the linguistic profile of children with autism spectrum disorder. Front Psychol 2020;11:808. https://doi.org/10.3389/fpsyg.2020.00808.
[13] Reindal L, Nærland T, Weidle B, Lydersen S, Andreassen OA, Sund AM. Structural and pragmatic language impairments in children evaluated for autism spectrum disorder (ASD). J Autism Dev Disord 2023;53(2):701–19. https://doi.org/10.1007/s10803-020-04853-1.
[14] Petruzzelli MG, Matera E, Giambersio D, Marzulli L, Gabellone A, Legrottaglie AR, Margari A, Margari L. Subjective and electroencephalographic sleep parameters in children and adolescents with autism spectrum disorder: a systematic review. J Clin Med 2021;10(17):3893. https://doi.org/10.3390/jcm10173893.
[15] Cann N. Getting a good night's sleep: sleep problems, their etiology, and potential interventions for children and adolescents with autism. Child Care Pract 2023;29(1):22–34. https://doi.org/10.1080/13575279.2022.2119938.
[16] Díaz-Román A, Zhang J, Delorme R, Beggiato A, Cortese S. Sleep in youth with autism spectrum disorders: systematic review and meta-analysis of subjective and objective studies. Evid Base Ment Health 2018;21(4):146–54. https://doi.org/10.1136/ebmental-2018-300037.
[17] Fletcher FE, Foster-Owens MD, Conduit R, Rinehart NJ, Riby DM, Cornish KM. The developmental trajectory of parent-report and objective sleep profiles in autism spectrum disorder: associations with anxiety and bedtime routines. Autism: the international journal of research and practice 2017;21(4):493–503. https://doi.org/10.1177/1362361316653365.
[18] Chen H, Yang T, Chen J, et al. Sleep problems in children with autism spectrum disorder: a multicenter survey. BMC Psychiatr 2021;21(1):406. https://doi.org/10.1186/s12888-021-03405-w.
[19] Kelmanson IA. Sleep disturbances and their associations with emotional/behavioural problems in 5-year-old boys with autism spectrum disorders. Early Child Dev Care 2020;190(2):236–51. https://doi.org/10.1080/03004430.2018.1464622.
[20] Phung JN, Goldberg WA. Poor sleep quality is associated with discordant peer relationships among adolescents with autism spectrum disorder. Research in autism spectrum disorders 2017;34(3):10–8. https://doi.org/10.1016/j.rasd.2016.11.008.
[21] Tudor ME, Hoffman CD, Sweeney DP. Children with autism: sleep problems and symptom severity. Focus on autism and other developmental disabilities 2012;27(4). https://doi.org/10.1177/1088357612457989.
[22] Beattie L, Kyle SD, Espie CA, Biello SM. Social interactions, emotion and sleep: a systematic review and research agenda. Sleep Med Rev 2015;24:83–100. https://doi.org/10.1016/j.smrv.2014.12.005.
[23] Hollway JA, Aman MG, Butter E. Correlates and risk markers for sleep disturbance in participants of the autism treatment network. J Autism Dev Disord 2013;43:2830–43. https://doi.org/10.1007/s10803-013-1830-y.
[24] Schreck KA, Mulick JA, Smith AF. Sleep problems as possible predictors of intensified symptoms of autism. Res Dev Disabil 2004;25(1):57–66. https://doi.org/10.1016/j.ridd.2003.04.007.
[25] Veatch OJ, Sutcliffe JS, Warren ZE, Keenan BT, Potter MH, Malow BA. Shorter sleep duration is associated with social impairment and comorbidities in ASD. Autism Res: Official Journal of the International Society for Autism Research 2017;10(7):1221–38. https://doi.org/10.1002/aur.1765.
[26] Hunter JE, McLay LK, France KG, Blampied NM. Systematic review of the collateral effects of behavioral sleep interventions in children and adolescents with autism spectrum disorder. Research in Autism Spectrum Disorders 2020;79:101677. https://doi.org/10.1016/j.rasd.2020.101677.
[27] McLay LL, France KG, Blampied NM, Hunter JE, Van Deurs JR, Woodford EC, Gibbs R, Lang R. Collateral child and parent effects of function-based behavioral interventions for sleep problems in children and adolescents with autism. J Autism Dev Disord 2022;52:2258–73. https://doi.org/10.1007/s10803-021-05116-3.
[28] Arazi A, Meiri G, Danan D, Michaelovski A, Flusser H, Menashe I, Tarasiuk A, Dinstein I. Reduced sleep pressure in young children with autism. Sleep 2020;43(6):309. https://doi.org/10.1093/sleep/zsz309.
[29] Nadeau JM, Arnold EB, Keene AC, Collier AB, Lewin AB, Murphy TK, Storch EA. Frequency and clinical correlates of sleep-related problems among anxious youth with autism spectrum disorders. Child Psychiatr Hum Dev 2015;46(4):558–66. https://doi.org/10.1007/s10578-014-0496-9.
[30] Richdale AL, Baglin CL. Self-report and caregiver-report of sleep and psychopathology in children with high-functioning autism spectrum disorder: a

pilot study. Dev Neurorehabil 2015;18(4):272–9. https://doi.org/10.3109/17518423.2013.829534.

[31] Abel EA, Schwichtenberg AJ, Brodhead MT, Christ SL. Sleep and challenging behaviors in the context of intensive behavioral intervention for children with autism. J Autism Dev Disord 2018;48(11):3871–84. https://doi.org/10.1007/s10803-018-3648-0.

[32] Cohen S, Fulcher BD, Rajaratnam SMW, Conduit R, Sullivan JP, St Hilaire MA, Phillips AJK, Loddenkemper T, Kothare SV, McConnell K, Braga-Kenyon P, Ahearn W, Shlesinger A, Potter J, Bird F, Cornish KM, Lockley SW. Sleep patterns predictive of daytime challenging behavior in individuals with low-functioning autism. Autism Res: official journal of the International Society for Autism Research 2018;11(2):391–403. https://doi.org/10.1002/aur.1899.

[33] Park S, Cho SC, Cho IH, Kim BN, Kim JW, Shin MS, Chung US, Park TW, Son JW, Yoo HJ. Sleep problems and their correlates and comorbid psychopathology of children with autism spectrum disorders. Research in autism spectrum disorders 2012;6(3):1068–72. https://doi.org/10.1016/j.rasd.2012.02.004.

[34] Sannar EM, Palka T, Beresford C, Peura C, Kaplan D, Verdi M, Siegel M, Kaplan S, Grados M. Sleep problems and their relationship to maladaptive behavior severity in psychiatrically hospitalized children with autism spectrum disorder (ASD). J Autism Dev Disord 2017;48(11):3720–6. https://doi.org/10.1007/s10803-017-3362-3.

[35] McLay L, France K, Blampied N, van Deurs J, Hunter J, Knight J, Lang R. Function-based behavioral interventions for sleep problems in children and adolescents with autism: summary of 41 clinical cases. J Autism Dev Disord 2020;51:418–32. https://doi.org/10.1007/s10803-020-04548-7.

[36] Taylor MA, Schreck KA, Mulick JA. Sleep disruption as a correlate to cognitive and adaptive behavior problems in autism spectrum disorders. Res Dev Disabil 2012;33 (5):1408–17. https://doi.org/10.1016/j.ridd.2012.03.013.

[37] Adams HL, Matson JL, Cervantes PE, Goldin RL. The relationship between autism symptom severity and sleep problems: should bidirectionality be considered? Research in Autism Spectrum Disorders 2014;8(3):193–9. https://doi.org/10.1016/j.rasd.2013.11.008.

[38] Verhoeff ME, Blanken LME, Kocevska D, Mileva-Seitz VR, Jaddoe VWV, White T, Verhulst F, Luijk MPCM, Tiemeier H. The bidirectional association between sleep problems and autism spectrum disorder: a population-based cohort study. Mol Autism 2018;30(9):8. https://doi.org/10.1186/s13229-018-0194-8.

[39] Levinson S, Eisenhower A, Bush HH, Carter AS, Blacher J. Brief report: predicting social skills from semantic, syntactic, and pragmatic language among young children with autism spectrum disorder. J Autism Dev Disord 2020;50(11): 4165–75. https://doi.org/10.1007/s10803-020-04445–z.

[40] Lord C, Elsabbagh M, Baird G, Veenstra-Vanderweele J. Autism spectrum disorder. Lancet 2018;392(10146):508–20. https://doi.org/10.1016/s0140-6736(18)31129-2.

[41] Botting N, Baraka N. Sleep behaviour relates to language skills in children with and without communication disorders. Int J Dev Disabil 2018;64(4–5):238–43.

[42] Geurts HM, Embrechts M. Language profiles in ASD, SLI, and ADHD. J Autism Dev Disord 2008;38(10):1931–43. https://doi.org/10.1007/s10803-008-0587-1.

[43] Volden J, Coolican J, Garon N, White J, Bryson S. Brief report: pragmatic language in autism spectrum disorder: relationships to measures of ability and disability. J Autism Dev Disord 2009;39(2):388–93. https://doi.org/10.1007/s10803-008-0618-y.

[44] Bonuck K, Battino R, Barresi I, McGrath K. Sleep problem screening of young children by speech-language pathologists: a mixed-methods feasibility study. Autism & Developmental Language Impairments 2021;6.

[45] Fletcher FE, Knowland V, Walker S, Gaskell MG, Norbury C, Henderson LM. Atypicalities in sleep and semantic consolidation in autism. Dev Sci 2020;23(3): 12906. https://doi.org/10.1111/desc.12906.

[46] Knowland VC, Fletcher F, Henderson LM, Walker S, Norbury CF, Gaskell MG. Sleep promotes phonological learning in children across language and autism spectra. J Speech Lang Hear Res 2019;62(12):4235–55. https://doi.org/10.1044/2019_JSLHR-S-19-0098.

[47] Knowland VC, Berens S, Gaskell MG, Walker SA, Henderson LM. Does the maturation of early sleep patterns predict language ability at school entry? A Born in Bradford study. J Child Lang 2022;49(1):1–23. https://doi.org/10.1017/S0305000920000677.

[48] Rutter M, Le Couteur A, Lord C. ADI-R; Entrevista Clínica Para el Diagnóstico del Autismo-Revisada. Madrid: TEA Ediciones; 2006.

[49] Lord C, Rutter M, DiLavore PC, Risi S. Autism diagnostic observation schedule-WPS (ADOS-WPS). Los Angeles: Western Psychological Services; 1999.

[50] Rutter M, Bailey A, Lord C. SCQ: the social communication questionnaire. Torrance, CA: Western Psychological Services; 2003.

[51] Bruni O, Ottaviano S, Guidetti V, Romoli M, Innocenzi M, Cortesi F, Giannotti F. The Sleep Disturbance Scale for Children (SDSC) Construct ion and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. J Sleep Res 1996;5(4):251–61. https://doi.org/10.1111/j.1365-2869.1996.00251.x.

[52] Pagerols M, Bosch R, Prat R, Pagespetit È, Cilveti R, Chaparro N, Esteve A, Casas M. The Sleep Disturbance Scale for Children: psychometric properties and prevalence of sleep disorders in Spanish children aged 6–16 years. J Sleep Res 2023;32(4): 13871. https://doi.org/10.1111/jsr.13871.

[53] Bishop DVM. The children's communication checklist (CCC-2). second ed. London: The Psychological Corporation; 2003. https://doi.org/10.1111/1469-7610.00388.

[54] Helland WA, Helland T, Heimann M. Language profiles and mental health problems in children with specific language impairment and children with ADHD. J Atten Disord 2014;18(3):226–35. https://doi.org/10.1177/1087054712441705.

[55] Wiig EH, Semel E, Secord WA. Clinical evaluation of Language fundamentals. fifth ed. NCS Pearson; 2013 *(CELF-5)*.

[56] Massa J, Gomes H, Tartter V, Wolfson V, Halperin JM. Concordance rates between parent and teacher clinical evaluation of language fundamentals observational rating scale. Int J Lang Commun Disord 2008;43(1):99–110. https://doi.org/10.1080/13682820701261827.

[57] Cohen-Addad V, Kanade V, Mallmann-Trenn F, Mathieu C. Hierarchical clustering: objective functions and algorithms. J ACM 2019;66(4):1–42. https://doi.org/10.1145/nnnnnnn.nnnnnnn.

[58] Dalmaijer ES, Nord CL, Astle DE. Statistical power for cluster analysis. BMC Bioinf 2022;23(1):1–28.

[59] Cohen J. Statistical power analysis for the behavioral Sciences. second ed. Hillsdale, NJ: Erlbaum; 1988. https://doi.org/10.4324/9780203771587.

[60] Kaufman AS, Kaufman NI. K-BIT. Test breve de Inteligencia de Kauffman. Madrid: Pearson; 2000.

[61] Wechsler D. Wechsler intelligence scale for children (WISC-IV). fourth ed. San Antonio, TX: The Psychological Corporation; 2003. https://doi.org/10.1037/t15174-000.

[62] Bishop DV. Development of the Children's Communication Checklist (CCC): a method for assessing qualitative aspects of communicative impairment in children. J Child Psychol Psychiatry Allied Discip 1998;39(6):879–91. https://doi.org/10.1111/1469-7610.00388.

[63] Henderson L, Powell A, Gareth Gaskell M, Norbury C. Learning and consolidation of new spoken words in autism spectrum disorder. Dev Sci 2014;17(6):858–71.

[64] Horváth K, Myers K, Foster R, Plunkett K. Napping facilitates word learning in early lexical development. J Sleep Res 2015;24(5):503–9. https://doi.org/10.1111/jsr.12306.

[65] Horváth K, Plunkett K. Frequent daytime naps predict vocabulary growth in early childhood. JCPP (J Child Psychol Psychiatry) 2016;57(9):1008–17. https://10.1111/jcpp.12583.

[66] Williams SE, Horst JS. Goodnight book: sleep consolidation improves word learning via storybooks. Front Psychol 2014;5:184.

[67] Tesfaye R, Wright N, Zaidman-Zait A, Bedford R, Zwaigenbaum L, Kerns CM, Duku E, Mirenda P, Bennett T, Georgiades S, Smith IM, Vaillancourt T, Pickles A, Szatmari P, Elsabbagh M. Investigating longitudinal associations between parent reported sleep in early childhood and teacher reported executive functioning in school-aged children with autism. Sleep 2021;44(9):122. https://doi.org/10.1093/sleep/zsab122.

[68] Razavi F, Pourmohamadreza-Tajrishi M, Haghgoo H, Bakhshi E, Tavakoli S, Seyed Mohammad Ali Miri SM. Relationship between executive functions and pragmatic language in children with autism spectrum disorders. Iranian rehabilitation journal 2019;17(3):225–34. https://doi.org/10.32598/irj.17.3.225.

[69] Calhoun SL, Pearl AM, Fernandez-Mendoza J, Durica KC, Mayes SD, Murray MJ. Sleep disturbances increase the impact of working memory deficits on learning problems in adolescents with high-functioning autism spectrum disorder. J Autism Dev Disord 2020;50(5):1701–13. https://doi.org/10.1007/s10803-019-03928-y.

[70] Williams Buckley A, Hirtz D, Oskoui M, Armstrong MJ, Batra A, Bridgemohan C, Ashwal S. Practice guideline: treatment for insomnia and disrupted sleep behavior in children and adolescents with autism spectrum disorder: report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology. Neurol Now 2020;94(9):392–404. https://doi.org/10.1212/WNL.0000000000009033.

[71] McCrae CS, Chan WS, Curtis AF, Deroche CB, Munoz M, Takamatsu S, Mazurek MO. Cognitive behavioral treatment of insomnia in school-aged children with autism spectrum disorder: a pilot feasibility study. Autism Res 2020;13(1): 167–76. https://doi.org/10.1002/aur.2204.

[72] Georén L, Jansson-Fröjmark M, Nordenstam L, Andersson G, Olsson NC. Internet-delivered Cognitive Behavioral Therapy for insomnia in youth with autism spectrum disorder: a pilot study. Internet interventions 2022;29. https://doi.org/10.1016/j.invent.2022.100548.

[73] Conti-Ramsden G, Durkin K, Toseeb U, Botting N, Pickles A. Education and employment outcomes of young adults with a history of developmental language disorder. Int J Lang Commun Disord 2018;53(2):237–55. https://doi.org/10.1111/1460-6984.12338.