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Adaptive behaviors and related factors in children and adolescents with autism spectrum disorder: Report from ELENA cohort

Ela Miniarikova [a,b], Lee Audras-Torrent [a,b], Mathilde Berard [a,b,c], Marianne Peries [a,b,c], Marie-Christine Picot [d,c,b], Kerim Munir [e], Amaria Baghdadli [a,b,c,f,*], for the ELENA study group

[a] Centre de Ressource Autisme Languedoc-Roussillon, CHU Montpellier, Montpellier, France
[b] Centre d'Excellence sur l'Autisme et les Troubles du Neurodéveloppement (CeAND), CHU Montpellier, France
[c] Université Paris-Saclay, UVSQ, Inserm, CESP, Team DevPsy, 94807, Villejuif, France
[d] Clinical Research and Epidemiology Unit, Department of Medical Information, University Hospital, CHU Montpellier, France
[e] Developmental Medicine Center, Boston Children's Hospital, Harvard Medical School, Boston, MA, USA
[f] Faculté de Médecine, Université de Montpellier, France

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ABSTRACT

There are strong individual differences in adaptive behaviors (AB) in autism spectrum disorder (ASD) with conflicting results in literature about specific patterns and related factors. The present study aims to describe AB and identify related factors in terms of clinical and socio-familial characteristics in 875 children and adolescents with ASD in the multiregional ELENA cohort in France. Results showed that AB in children and adolescents with ASD were lower than in typically developing subjects, regardless of age group. AB were associated with clinical (gender, age at diagnosis, IQ, ASD severity, psychiatric comorbidities, motor and language skills, challenging behaviors), interventional (school attendance, special interventions) and familial characteristics (age, educational and socio-economic status of parents, household status, number of siblings). There is a need of interventions focusing on improvement of AB, tailored to children's characteristics.

1. Introduction

Autism Spectrum Disorder (ASD) is a complex and highly heterogeneous neurodevelopmental disorder characterized by impairments in social communication associated with restricted patterns of behaviors, interests, or activities across multiple contexts and persisting over time. Knowledge of adaptive functioning is important in assessment of children and adolescents with ASD, especially since many have comorbid conditions including intellectual disability (ID) in addition to other neurodevelopmental, mental and behavioral disorders. Adaptive behaviors (AB) refers to skills in conceptual, social and practical domains that is characteristically measured by means of parental or caregivers' interviews. There are strong differences across individuals with ASD in their AB profiles considered as a key component of clinical heterogeneity and outcome (Baghdadli et al., 2012; Kraper et al., 2017; Tillmann et al., 2019). In addition, deficits in AB are considered a key criterion for diagnosis of ID, as well as an arbiter of its severity levels determining the intensity of supports required (American Psychiatric Association, 2013). The severity specifiers of ASD, on the other hand, include degree of symptom loading in the social communication and restricted/repetitive behavior domains.

It has been suggested that individuals with ASD have lower AB compared to those with typical development (TD) (Kraper et al., 2017; Tillmann et al., 2019), especially in terms of socialization and communication (Del Cole et al., 2017; Liss et al., 2001; Mouga et al., 2015; Ray-Subramanian et al., 2011; Tillmann et al., 2019). In addition, studies have identified that children and adolescents with ASD have specific patterns of AB profiles across the Vineland Adaptive Behavior Scales (VABS) (Sparrow et al., 2005; Sparrow and Cicchetti, 1989). Number of studies have noted the VABS domains as being highest for motor skills, followed by daily living skills, socialization, and communication (Nevill et al., 2017; Ray-Subramanian et al., 2011). In contrast,

* Corresponding author. Centre de Ressource Autisme Languedoc-Roussillon & Centre d'Excellence sur l'Autisme et les Troubles Neuro-développementaux (CeAND), 39 Avenue Charles Flahaut, 34295, Montpellier, cedex 05, France.
E-mail addresses: e-miniarikova@chu-montpellier.fr (E. Miniarikova), l-audras-torrent@chu-montpellier.fr (L. Audras-Torrent), mathilde-berard@chu-montpellier.fr (M. Berard), m-peries@chu-montpellier.fr (M. Peries), mc-picot@chu-montpellier.fr (M.-C. Picot), kerim.munir@childrens.harvard.edu (K. Munir), rech-clinique-autisme@chu-montpellier.fr (A. Baghdadli).

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Matthews et al. (2015) described the VABS communication as a strength in children and adolescents with ASD.

Many studies have examined the factors related to individual differences in AB among children with ASD, mainly measured using the VABS. It has been suggested that child age is positively correlated with VABS raw scores (Matthews et al., 2015), but negatively with VABS standard scores (Klin et al., 2007) suggesting that AB improved with age albeit at a lower rate than in TD children. Findings on possible link between gender and AB in ASD have been conflicting, with better skills described respectively in females (Mandic-Maravic et al., 2015), males (Ratto et al., 2018) or no gender differences (Pathak et al., 2019). Many studies (Chang et al., 2013; Chatham et al., 2018; Klin et al., 2007; Pathak et al., 2019; Perry et al., 2009; Puig et al., 2013; Ray-Subramanian et al., 2011; Tillmann et al., 2019) found that intellectual quotient (IQ) of children with ASD was positively associated with their AB, especially in terms of communication (Kenworthy et al., 2010; Klin et al., 2007; Mazefsky et al., 2008; Perry et al., 2009). Liss et al. (2001) have suggested that these associations between AB and IQ were stronger in low-cognitive-functioning individuals. More recent studies have stressed that individuals with ID had higher adaptive than intellectual skills compared to those without ID (Flanagan et al., 2015; Matthews et al., 2015; Perry et al., 2009; Yang et al., 2016). Studies have shown that AB were negatively associated with ASD symptom severity with stronger correlations in children without ID (Frost et al., 2017; Hill et al., 2015; Liss et al., 2001). Tillmann et al. (2019) showed that greater severity in social and communication impairments was associated with lower AB. Higher language skills during childhood were also more likely to be associated with better AB (Baghdadli et al., 2007; Szatmari et al., 2015). In addition, other studies reported that the early use of a functional language (Baghdadli et al., 2012) and the onset of first words at 24 months (Mayo et al., 2013) were strongly predictive of positive AB trajectories. Studies have suggested that motor skills were positively linked to AB in toddlers (MacDonald et al., 2013) and school-aged children (Bremer and Cairney, 2018), particularly for daily living and socialization skills. There is no consensus on the relationship between challenging behaviors and adaptive skills in ASD, some studies suggesting that greater behavioral problems are associated with negative adaptive trajectories (Franchini et al., 2018) and others noting that this link is influenced by behavioral problem type and not necessarily severity (Park et al., 2012). Also, Baeza-Valesco et al. study (2014) suggested that while positive adaptive trajectories for communication and socialization were associated with less challenging behaviors, negative adaptive trajectories were not associated with the more challenging behaviors. Most studies examining the relationship between AB and psychiatric or medical comorbidities among children with ASD showed that those who had the best adaptive trajectories had no associated comorbidities. Other studies have stressed that lower AB were related to higher rates of psychiatric disorders such as anxiety and depression (Kraper et al., 2017), attention deficit/hyperactivity disorder (ADHD; (Kraper et al., 2017; Scandurra et al., 2019), epilepsy (Baghdadli et al., 2012), genetic syndrome, congenital malformation (Baghdadli et al., 2007) or perinatal complications (Traver et al., 2021). In contrast, Tillmann et al. (2019) showed that AB were not associated with psychiatric disorders such as ADHD, anxiety and depression.

In addition, interventions or support received by children with ASD, or by their parents, appeared to be protective of the child's AB (Baghdadli et al., 2012; Bal et al., 2015; Remington et al., 2007). Also, this protective effect for AB may be related to the possibility of attending school irrespective of regular or special education settings (Rattaz et al., 2020).

By observing familial configuration, studies have reported that parents' social class was not related to AB among children with ASD (Baghdadli et al., 2012), while others found that negative adaptive outcome were related to lower income and education level (Del Cole et al., 2017; Kilincaslan et al., 2019). Also, recent studies suggested that children with ASD who have siblings had better adaptive trajectories (Rosen et al., 2022).

Overall, despite a large number of studies, results about the patterns of AB in people with ASD and the related factors are not consensual. Our first objective was to investigate AB of children and adolescents with ASD. Secondly, we aimed to identify related factors to AB including clinical presentation, school attendance, interventions, and socio-familial characteristics.

2. Methods

2.1. Participants and procedure

Eight hundred and seventy-five participants with a confirmed ASD diagnosis (aged 2–16 years) came from the ELENA cohort, a French ongoing prospective and multicentric study (Baghdadli et al., 2019). Informed consent of the parent's participants was obtained after the nature of the procedures had been fully explained. Parents completed online questionnaires and medical and interventional reports (Baghdadli et al., 2019). The inclusion criterion for this study was the availability of the three VABS-II scores (communication, daily living skills, and socialization) at inclusion. We considered three age groups using developmental stages, and schooling age periods: young children ([2–6 [years); latency age children ([6–12[years); and adolescents (over 12 years). The investigation was carried out in accordance with the latest version of the Declaration of Helsinki. The study was approved by the South Mediterranean Ethics Committee on the Research of Human Subjects of Marseille (ID RCB: 2014-A01423-44) and the National Commission for Computing and Liberties (CNIL. number DR-2015-393).

2.2. Measures

Adaptive behaviors were assessed using the French form of the Vineland Adaptive Behavior Scale-II (VABS-II) (Sparrow et al., 2005), a standardized semi-structured parent/caregiver interview. We used three subscores of VABS-II: communication, daily living skills and socialization. The standard mean score is 100 (standard deviation; SD = 15) with lower scores indicating greater impairment. Test reliability was 0.88, and internal consistency, 0.94.

Children's clinical characteristics: *ASD Symptom severity* was measured using the Calibrated Severity Score (CSS) of ADOS-2 (Gotham et al., 2008; Lord et al., 2012). *The intellectual quotient* (IQ) was estimated for each child using age-appropriate standardized tests (Wechsler scales (Wechsler, 2008; 2014a; 2014b); K-ABC II (Kaufman and Kaufman, 2014)) or developmental scales (Brunet Lézine-Revised (Brunet et al., 1997) or PEP-3 (Schopler et al., 2010) for which best estimate IQ was calculated according to Stern's formula (Stern, 1912). *Motor skills* were assessed with the Motor Functional Development Scale for Young Children (DF-MOT), a developmental tool assessing both gross and fine motor skills (Vaivre-Douret, 2003) for children from 0 to 48 months of age; and with the Movement Assessment Battery for Children (M-ABC) (Brown and Lalor, 2009) and M-ABC 2 (Henderson et al., 2007): for children 3–16 years of age. *Psychiatric comorbidities* were evaluated with the Child Behavior Check List (CBCL) (Achenbach and Ruffle, 2000) assessing emotional and behavioral disorders in children from 6 to 18 years of age, consisting of five DSM-oriented scales (affective problems, anxiety problems, pervasive problems, attention deficit, oppositional problems). *Child challenging behaviors* were screened with the Aberrant Behavior Checklist (ABC) (Aman and Singh, 1994), a 58-item behavior rating scale that measures behavioral problems across four factors: irritability, lethargy/withdrawal, stereotypy and hyperactivity. *The overall level of language* was assessed using item 19 from Autism Diagnostic Interview (ADI) (Le Couteur et al., 1989) and item 30 from Autism Diagnostic Interview-Revised (ADI-R) (Rutter et al., 2003), a standardized semi-structured parent/caregiver interview exploring child early development. The Peabody Picture Vocabulary Test-Revised (EVIP) (Dunn et al., 1993) was used to assess the overall receptive level of

vocabulary and the Preschool Language Scales-5 Screening Test (PLS-5) (Zimmerman et al., 2011) to screen a broad range of speech and language skills.

School, interventions and familial characteristics: Data about school attendance (regular class, special class or no school), specialized interventions and familial characteristics (age, educational and socio-economic status (SES) of parents; household status and number of siblings) were extracted from the ELENA socio-demographic report.

2.3. Statistical analysis

The outcomes were the VABS-II standard scores for communication, daily living skills, and socialization at inclusion, which corresponds to diagnosis time. The explanatory variables included child's clinical characteristics (age at diagnosis, gender, language skills, psychiatric comorbidities, motor skills, IQ, ASD symptoms severity, challenging behaviors); school and specialized interventions; and familial characteristics (parents' age, SES, and educational level, household, number of siblings).

Means and SD were reported for continuous variables, and frequency and percentage for categorical variables. The association between potential explanatory variables and the outcomes were studied using ANOVA for categorical variables and Spearman's correlations for the continuous variables. The strength of the association was considered as weak for a correlation coefficient from 0.1 to 0.3, moderate from 0.3 to 0.5, and strong for a coefficient over 0.5 (Cohen, 1992). Pairwise comparisons were made using the Bonferroni post-hoc test. Paired-sample Wilcoxon signed rank tests were performed to examine whether the three VABS-II scores were significantly different from each other.

All statistical tests were considered significant for $p < .05$. Statistical analyses were performed using SAS Enterprise Guide V7.13 (SAS Institute Inc., Cary, NC, USA).

3. Results

The study sample included 875 children and adolescents with a mean age of 6.9 years (SD = 3.3). Daily living skills (Mean = 73.4; SD ± 12.8) were higher than communication (69.9 ± 15.3) and socialization (69.9 ± 10.7) ($p < .001$). Analyses were done for three age groups: young children ($n = 545$, 62.3%); latency age children ($n = 268$, 30.6%); and adolescents ($n = 62$, 7.1%).

Clinical characteristics of each age group are described in Table 1.

3.1. Young children ([2–6[years; n = 545)

The subgroup mean age was 3.8 years (SD ± 1.1) with 453 males (83.1%) (see Table 1). Communication score was 67.1 (SD ± 14.8), daily living skills score was 73.3 (±12.9) and socialization score was 70.5 (±9.9). The association between interventions, clinical and familial characteristics and the three VABS-II scores in young children are described in Table 2.

3.1.1. Clinical characteristics

Boys had higher adaptive scores than girls for communication ($p = .05$) and daily living skills ($p = .04$). Socialization was weakly and negatively correlated with child age at diagnosis ($r = -0.17$, $p < .001$). The three VABS-II scores were strongly and positively correlated with IQ (communication: $r = 0.64$; daily living skills: $r = 0.57$, socialization: $r = 0.52$, all $p < .001$), but weakly and negatively with ASD severity (communication: $r = -0.28$; daily living skills: $r = -0.23$, socialization: $r = -0.24$, all $p < .001$) and challenging behaviors (communication: all r = [-0.28;-0.16]; daily living skills: all r = [-0.34;-0.20], socialization: all r = [-0.42;-0.26], all $p < .001$). Higher affective and pervasive problems, identified with CBCL, were associated with lower VABS-II scores (all $p < .051$). Higher oppositional problems were also associated with lower daily living skills ($p = .03$). Language skills assessed across the PLS-5 score were positively correlated with daily living skills and socialization (respectively, $r = 0.58$ $p < .001$ and $r = 0.34$, $p = .02$). Higher early language skills, assessed by the ADI, were associated with higher AB for all VABS-II domains (all $p < .001$). Higher DF-MOT global motor skills were correlated with higher daily living skills ($r = 0.25$, $p = .02$).

3.1.2. School and interventions

Children attending regular class had higher communication than those who were not attending school or attending special class ($p = .03$). Socialization were higher for children who were not attending school compared to those attending special class ($p = .02$). Children who were receiving specialized interventions had lower communication than those who were not ($p = .05$).

3.1.3. Familial characteristics

Higher communication and socialization were associated with higher parental educational levels and high SES (all $p < .01$). Children had higher daily living skills when parents were living together ($p = .01$) and had high SES ($p = .002$).

3.2. Latency age children ([6–12[years; n = 268)

The subgroup mean age was 8.5 years (SD = 1.7) with 217 males (81.0%). Communication score was 75.5 (SD ± 15.5), daily living skills score was 74.8 (±12.6) and socialization score was 70.2 (±11.9). The association between interventions, clinical and familial characteristics and the three VABS-II scores inlatency age children are described in Table 3.

3.2.1. Clinical characteristics

IQ was strongly and positively correlated with AB in terms of communication, daily living skills, and socialization (respectively, $r = 0.62$, 0.45, and 0.39, all $p < .001$). ASD severity was weakly and negatively correlated with all areas of AB (communication: $r = -0.64$; daily living skills: $r = -0.18$, socialization: $r = -0.18$, all $p = .01$). Lethargy and stereotypy assessed across ABC were negatively and moderately linked to communication, daily living skills, and socialization ($r = -0.22$, $p = .001$ for lethargy; $r = -0.30$, $p < .001$ for stereotypy) whereas irritability ABC scores were negatively and weakly related to daily living skills ($r = -0.34$, $p = .03$) and socialization ($r = -0.34$, $p = .1$). Lexical comprehension score assessed with EVIP was moderately and positively correlated to communication ($r = .46$, $p < .001$) and weakly correlated to daily living skills ($r = 0.23$, $p = .01$). Higher early language skills on the ADI were associated with higher communication ($p < .001$), daily living skills ($p < .001$), and socialization ($p < .001$). Motor skills assessed with M-ABC were significantly associated with higher scores on all VABS-II domains.

3.2.2. School and interventions

The three VABS-II scores are significantly lower in children who were not attending school. Children in specialized institutions had lower communication ($p = .003$) and socialization than those who were not ($p = .01$).

3.2.3. Familial characteristics

Children had higher communication when both parents had high educational and SES levels (all $p = .01$). Children had higher socialization when mothers had high education level ($p = .01$). Higher communication and socialization were found when parents were living together (all $p = .04$).

3.3. Adolescents (≥12 years; n = 62)

The subgroup mean age was 13.9 years (±1.4) with 54 males (87.1%). Communication score was 71.5 (SD ± 12.6), daily living skills

Table 1
Clinical characteristics for each age group.

	Young children ([2–6[years)	Latency age children ([6–12[years)	Adolescents (≥12 years)
	N = 545	*N = 268*	*N = 62*
Gender			
Boys	453 (83.13%)	217 (80.97%)	54 (87.10%)
Girls	92 (16.88%)	51 (19.30%)	8 (12.9%)
Age at inclusion visit	3.79 (±1.09)	8.46 (±1.69)	13.93 (±1.36)
IQ	65.32 (±22.49)	84.70 (±28.01)	88.69 (±26.81)
VABS-II scales			
Communication	67.05 (±14.79)	75.47 (±15.49)	71.45 (±12.56)
Daily Living Skills	73.25 (±12.86)	74.80 (±12.59)	68.19 (±11.98)
Socialization	70.54 (±9.93)	70.15 (±11.94)	63.23 (±9.99)
ASD symptom severity (ADOS-2 CSS)	*N = 464*	*N = 260*	*N = 51*
	7.170 (±1.841)	6.673 (±2.088)	7.431 (±2.283)
Psychiatric comorbidities (CBCL)	*N = 282*	*N = 158*	*N = 39*
Affective problems			
Borderline/clinical	129 (45.74%)	109 (69.43%)[a]	28 (71.79%)
Normal range	153 (54.26%)	48 (30.57%)	11 (28.21%)
Anxiety problems			
Borderline/clinical	74 (26.24%)	113 (71.52%)	30 (76.92%)
Normal range	208 (73.76%)	45 (28.48%)	9 (23.08%)
ADHD			
Borderline/clinical	67 (23.76%)	76 (48.41%)	14 (35.90%)
Normal range	215 (76.24%)	81 (51.59%)[a]	25 (64.10%)
Oppositional problems			
Borderline/clinical	56 (19.86%)	45 (28.48%)	11 (28.21%)
Normal range	226 (80.14%)	113 (71.52%)	28 (71.79%)
Pervasive problems (only <6 years)			
Borderline/clinical	210 (80.15%)[c]	–	–
Normal range	52 (19.85%)		
Somatic problems (only ≥6 years)			
Borderline/clinical	–	32 (20.51%)[b]	12 (30.77%)
Normal range		124 (79.49%)	27 (69.23%)
Conduct problems (only ≥6 years)			
Borderline/clinical	–	41 (26.11%)[a]	11 (28.21%)
Normal range		116 (73.89%)	28 (71.79%)
Challenging behaviors (ABC)	*N = 297*	*N = 160*	*N = 41*
Irritability	35.41 (±19.86)[a]	31.21 (±20.56)[a]	33.71 (±28.30)
Lethargy/withdrawal	26.69 (±17.74)[b]	25.84 (±17.93)[a]	36.79 (±23.90)
Stereotypy	31.51 (±23.73)[b]	33.45 (±24.32)[a]	29.73 (±23.32)
Hyperactivity	46.30 (±23.41)	41.784 (±22.053)	36.43 (±27.26)
Global Motor skills (DF-MOT)	*N = 85*	–	–
	12.00 (12.00–24.00)		
Motor skills (M-ABC)	*N = 63*	*N = 133*	*N = 36*
Clinical	39 (61.90%)	91 (68.42%)	8 (22.22%)
Normal range	24 (38.10%)	42 (31.58%)	28 (77.78%)
Language on ADI	*N = 387*	*N = 247*	*N = 57*
Phrases	141 (36.43%)	203 (82.19%)	50 (87.72%)
Words	86 (22.22%)	20 (8.10%)	2 (3.51%)
Less than 5 words	160 (41.34%)	24 (9.72%)	5 (8.77%)
Language: EVIP	*N = 64*	*N = 116*	*N = 29*
	34.50 (26.00–44.00)	84.00 (53.00–113.50)	168.00 (119.00–261.00)
Language: PLS	*N = 47*	–	–
	14.00 (9.00–21.00)		

Data are given in mean (±SD), median (IQR) or n(%).
[a] 1 missing data.
[b] 2 missing data.
[c] 20 missing data.

score was 68.2 (±12.0) and socialization score was 63.23 (±10.0). The association between interventions, clinical and familial characteristics and the three VABS-II scores in adolescents are described in Table 4.

3.3.1. Clinical characteristics

IQ was strongly positively correlated with the three VABS-II scores (communication: $r = 0.61$; daily living skills: $r = 0.52$, socialization: $r = 0.47$, $p = .001$). ASD severity was negatively and moderately correlated with communication and socialization (respectively, $r = -0.39$, and -0.46, $p < .01$). Challenging behaviors were moderately and negatively correlated with the three VABS-II scores except hyperactivity score, which was not correlated with daily living skills (communication: all $r =$ [-0.46;-0.36]; daily living skills: $r =$ [-0.56;-0.39], all $p < .001$). Among the psychiatric comorbidities, only affective problems were associated

Table 2
Association between interventions, clinical and familial characteristics and the three VABS-II scores in young children.

	SS Communication			SS Daily living skills			SS Socialization		
		*p*value	Post hoc test		*p*value	Post hoc test		*p*value	Post hoc test
Clinical characteristics									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		
Gender		**.05**			**.04**			.54	
Boys (n = 453)	67.6 ± 14.6			**73.7 ± 12.7**			70.6 ± 9.9		
Girls (n = 92)	64.5 ± 15.5			**71.2 ± 13.6**			70.0 ± 10.2		
Psychiatric comorbidities (CBCL)									
Affective problems		**.02**			.001			**.001**	
Borderline/clinical (n = 129)	**66.7 ± 15.2**			**72.3 ± 13.6**			**68.9 ± 9.9**		
Normal range (n = 153)	**70.6 ± 12.8**			**77.0 ± 1.0**			**73.1 ± 9.5**		
Anxiety problems		.22			.58			.37	
Borderline/clinical (n = 74)	70.6 ± 16.2			74.1 ± 12.6			70.7 ± 10.6		
Normal range (n = 208)	68.2 ± 13.2			75.1 ± 12.4			71.3 ± 9.6		
ADHD		.95			.28			.13	
Borderline/clinical (n = 67)	68.7 ± 15.2			73.4 ± 12.2			69.7 ± 9.5		
Normal range (n = 215)	68.8 ± 13.8			75.3 ± 12.5			71.6 ± 10.0		
Oppositional problems		.06			.03			.06	
Borderline/clinical (n = 56)	69.2 ± 8.8			**71.6 ± 11.8**			69.2 ± 8.8		
Normal range (n = 226)	71.6 ± 10.1			**75.6 ± 12.5**			71.6 ± 10.1		
Pervasive problems		**.001**			**<.001**			**<.001**	
Borderline/clinical (n = 210)	**66.9 ± 13.5**			**73.0 ± 12.5**			**69.3 ± 8.9**		
Normal range (n = 52)	**74.1 ± 14.8**			**80.9 ± 11.0**			**77.7 ± 9.6**		
Motor skills (M-ABC)		.07			.86			.46	
Clinical (n = 39)	77.1 ± 14.6			80.1 ± 11.7			73.6 ± 10.4		
Normal range (n = 24)	83.8 ± 12.0			80.7 ± 13.5			75.5 ± 8.4		
Language on ADI		**<.001**			**<.001**			**<.001**	
Phrases (n = 141)	**77.9 ± 14.11**			**79.5 ± 11.3**			**73.7 ± 9.8**		
Words (n = 86)	**69.1 ± 13.0**			**74.5 ± 13.4**			**70.0 ± 10.6**		
Less than 5 words (n = 160)	**58.9 ± 12.1**			**67.1 ± 11.8**			**66.9 ± 8.6**		
SPEARMAN CORRELATIONS	rho			rho			rho		
Age at diagnosis (n = 414)	.09	.07		−.02	.74		**−.17**	**<.001**	
IQ (n = 545)	**.64**	**<.001**		**.57**	**<.001**		**.52**	**<.001**	
ASD symptom severity (ADOS-2 CSS) (n = 464)	**−.28**	**<.001**		**−.23**	**<.001**		**−.24**	**<.001**	
Global Motor skills (DF-MOT) (n = 85)	.15	.17		.25	**.02**		.01	.94	
Language: EVIP (n = 64)	**.27**	**.03**		.199	.11		.16	.21	
Language: PLS (n = 47)	**.62**	**<.001**		**.58**	**<.001**		**.34**	**.02**	
Challenging behaviors (ABC)									
Irritability (n = 296)	**−.16**	**.01**		**−.20**	**.001**		**−.26**	**<.001**	
Lethargy/withdrawal (n = 295)	**−.27**	**<.001**		**−.28**	**<.001**		**−.42**	**<.001**	
Stereotypy (n = 295)	**−.28**	**<.001**		**−.35**	**<.001**		**−.34**	**<.001**	
Hyperactivity(n = 297)	**−.21**	**<.001**		**−.23**	**<.001**		**−.34**	**<.001**	
Schooling and interventions									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		
Schooling		**.03**	Regular ≠ spe, no school		.06			**.02**	Spe≠no school
Regular (n = 207)	**69.9 ± 16.1**			74.6 ± 13.0			**70.8 ± 10.4**		
Special (n = 10)	**60.2 ± 10.3**			66.1 ± 14.1			**63.7 ± 8.2**		
No schooling (n = 81)	**65.9 ± 12.4**			72.1 ± 12.0			**72.2 ± 9.2**		

(*continued on next page*)

Table 2 (*continued*)

	SS Communication			SS Daily living skills			SS Socialization		
		*p*value	Post hoc test		*p*value	Post hoc test		*p*value	Post hoc test
Specialized institutions		**.05**			.20			.13	
Yes (n = 164)	66.8 ± 14.8			72.7 ± 12.8			70.2 ± 10.6		
No (n = 155)	70.0 ± 15.3			74.5 ± 13.0			71.8 ± 9.6		
Familial characteristics									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		
Mother's educational level		**.01**			.07			**.003**	
Elementary/High School (n = 125)	**65.8 ± 13.6**			72.1 ± 13.0			**69.3 ± 9.6**		
University (n = 187)	**70.2 ± 15.9**			74.9 ± 12.7			**72.2 ± 10.2**		
Father's educational level		**.02**			.26			**.02**	
Elementary/High School (n = 150)	**66.6 ± 13.0**			72.7 ± 12.2			**69.9 ± 9.1**		
University (n = 160)	**70.7 ± 16.6**			74.4 ± 13.7			**72.2 ± 10.7**		
SES		**<.001**	High≠ low		**.002**	High≠ low		**.001**	low≠ high, middle
High (n = 102)	**73.1 ± 15.8**			**76.8 ± 11.8**			**73.0 ± 9.1**		
Middle (n = 83)	**68.7 ± 15.0**			**74.1 ± 14.0**			**72.3 ± 11.1**		
Low (n = 132)	**64.7 ± 13.8**			**70.8 ± 12.7**			**68.6 ± 9.7**		
Family status		.16			**.01**			.06	
Parents live together (n = 272)	69.1 ± 14.8			**74.5 ± 12.8**			71.4 ± 10.0		
Parents do not live together(n = 54)	64.9 ± 17.2			**69.5 ± 12.8**			68.6 ± 10.1		
SPEARMAN CORRELATIONS	rho			rho			rho		
Mother age (n = 395)	.14	.01						.71	
Father age (n = 392)	**.11**	**.03**		−.07	.18		−.03	.61	
Number of siblings (n = 498)	−.08	.07		**−.13**	**.004**		−.07	.11	

Data are given in mean (±SD) or Spearman's rho.
Significant results: p < .05.
SS means Standard score. CSS means Calibrated Severity Score.

with lower socialization ($p = .04$). Lexical comprehension (EVIP) was strongly correlated with communication, daily living skills, and socialization (respectively $r = .81, .54$, and $0.59, p < .001$). Higher motor skills (M-ABC) were associated with higher communication ($p = .002$) and higher daily living skills ($p = .04$).

3.3.2. *School and interventions*

Children receiving specialized institutions had lower daily living skills ($p = .03$) and socialization than those who did not ($p = .04$).

3.3.3. *Familial characteristics*

Children had higher daily living skills ($p = .02$) when fathers had higher education level and had the three VABS-II scores higher when mothers had higher education level. Children' socialization was positively correlated with mothers' age at ASD diagnosis ($r = 0.32, p = .03$). Higher children communication ($p = .01$) and daily living skills ($p = .02$) were found when parents were not living together.

4. Discussion

The first objective of this study was to investigate AB in a large sample of 875 children and adolescents with confirmed ASD diagnosis followed-up in a multiregional prospective cohort (Baghdadli et al., 2019). Consistent with previous studies (Kraper et al., 2017; Tillmann et al., 2019), participants in our sample had lower adaptive skills compared to TD subjects (VABS-II norm groups), regardless of age group. Consistent with literature, we also found specific patterns in adaptive skills (i.e. daily living skills are higher than socialization and communication) for the whole sample. Plus, we found strength in communication in adolescents (Del Cole et al., 2017; Liss et al., 2001; Matthews et al., 2015; Mouga et al., 2015; Ray-Subramanian et al., 2011; Tillmann et al., 2019). Studies reporting weaknesses in the communication VABS domain used samples of very young children (under 46 months) whereas those reporting strengths in communication used samples of older participants. As noted by Matthews et al. (2015), who drew attention on an increase of AB with age, we found an increase only in communication skills. This result highlights the need to tailor interventions that target the improvement of life skills and socialization to all ages. In our study, the communication strengths found in the older participants could be explained, on the one hand, by the improvement of expressive language with age and, on the other hand, by the observation that the subdomain of writing is a strength of children with autism who appreciate the structured nature of reading and writing tasks.

The second objective of our study was to identify the factors related to AB in ASD. We found a relationship with child's gender for young children, as also described by Ratto et al. (2018), with boys having higher communication and daily living skills than girls. Consistent with multiple studies (Chang et al., 2013; Chatham et al., 2018; Klin et al., 2007; Pathak et al., 2019; Perry et al., 2009; Puig et al., 2013; Ray-Subramanian et al., 2011), we also found a positive association with IQ regardless of age group affiliation. These finding need to be expanded by longitudinal studies to explore adaptive trajectories according to IQ, previous studies suggesting that children with co-occurring ASD and ID had low-growth adaptive trajectories (Baghdadli et al., 2012; 2018) and

Table 3
Association between interventions, clinical and familial characteristics and the three VABS-II scores in latency age children.

	SS Communication			SS Daily living skills			SS Socialization		
		pvalue	Post hoc test		pvalue	Post hoc test		pvalue	Post hoc test
Clinical characteristics									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		
Gender		.77			.10			.97	
Boys (n = 217)	75.8 ± 15.5			75.4 ± 12.3			70.2 ± 12.2		
Girls (n = 51)	74.1 ± 15.4			72.2 ± 13.6			70.1 ± 10.9		
Psychiatric comorbidities (CBCL)									
Affective problems		.21			.46			.13	
Borderline/clinical(n = 109)	77.9 ± 14.3			75.4 ± 11.2			70.1 ± 9.8		
Normal range (n = 48)	74.6 ± 17.0			75.1 ± 13.9			72.9 ± 13.4		
Anxiety problems		.76			.62			.82	
Borderline/clinical(n = 113)	77.3 ± 13.7			75.6 ± 11.1			70.7 ± 10.6		
Normal range (n = 45)	75.5 ± 18.5			74.5 ± 14.0			71.2 ± 12.3		
ADHD		.79			.81			.45	
Borderline/clinical (n = 76)	77.2 ± 15.0			75.1 ± 11.2			70.3 ± 9.9		
Normal range (n = 81)	76.5 ± 15.5			75.5 ± 12.9			71.6 ± 12.1		
Oppositional problems		.21			.95			.38	
Borderline/clinical (n = 45)	79.4 ± 15.4			75.4 ± 12.3			69.8 ± 10.5		
Normal range (n = 113)	76.1 ± 15.3			75.5 ± 12.2			71.7 ± 11.5		
Somatic problems		.27			.75			.06	
Borderline/clinical (n = 32)	79.7 ± 16.6			76.0 ± 13.6			67.8 ± 9.5		
Normal range (n = 124)	76.4 ± 14.7			75.3 ± 11.6			71.9 ± 11.3		
Conduct problems		.75			.98			.81	
Borderline/clinical (n = 41)	76.2 ± 15.4			75.3 ± 12.2			70.6 ± 11.4		
Normal range (n = 116)	77.1 ± 15.2			75.3 ± 12.0			71.1 ± 11.0		
Motor skills (M-ABC)		**.002**			**<.001**			**.02**	
Clinical (n = 91)	**76.2 ± 13.3**			**74.2 ± 10.7**			**69.9 ± 11.4**		
Normal range (n = 42)	**84.1 ± 12.5**			**81.8 ± 10.4**			**74.2 ± 9.2**		
Language on ADI		**<.001**	Phrases ≠words, less than 5 words		**<.001**	Phrases ≠words, less than 5 words		**<.001**	Phrases ≠words, less than 5 words
Phrases (n = 203)	**79.2 ± 13.9**			**77.2 ± 11.6**			**72.3 ± 11.4**		
Words (n = 20)	**62.9 ± 10.8**			**66.0 ± 11.2**			**61.5 ± 8.8**		
Less than 5 words (n = 24)	**55.0 ± 10.9**			**62.1 ± 11.8**			**58.2 ± 8.9**		
SPEARMAN CORRELATIONS	rho			rho			rho		
Age at diagnosis (n = 116)	.08	.42		−.04	.68		−.11	.23	
IQ (n = 268)	**.62**	**<.001**		**.45**	**<.001**		**.39**	**<.001**	
ASD symptom severity (ADOS-2 CSS) (n = 260)	**−.15**	**.01**		**−.18**	**.003**		**−.18**	**.004**	
Language: EVIP (n = 116)	**.46**	**<.001**		**.23**	**.01**		.17	.06	
Challenging behaviors (ABC) (n = 159)									
Irritability	−.13	.10		**−.17**	**.03**		**−.22**	**.01**	
Lethargy/withdrawal	**−.27**	**.001**		**−.26**	**.001**		**−.30**	**<.001**	
Stereotypy	**−.37**	**<.001**		**−.33**	**<.001**		**−.34**	**<.001**	
Hyperactivity	−.08	.30		−.07	.38		−.15	.05	
Schooling and interventions									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		

(*continued on next page*)

Table 3 (*continued*)

	SS Communication			SS Daily living skills			SS Socialization		
		pvalue	Post hoc test		pvalue	Post hoc test		pvalue	Post hoc test
Schooling		**<.001**	Regular≠ spe≠ no school		**<.001**	No school≠ Regular, Spe		**<.001**	No school≠ Regular, Spe
Regular (n = 137)	**80.5 ± 13.6**			**77.4 ± 11.3**			**73.1 ± 10.9**		
Special (n = 27)	**68.6 ± 9.3**			**73.1 ± 11.9**			**68.3 ± 10.0**		
No schooling (n = 14)	**49.8 ± 7.9**			**58.7 ± 11.9**			**55.6 ± 9.8**		
Specialized institutions		**.003**			.06			**.01**	
Yes (n = 93)	**71.9 ± 16.7**			73.2 ± 14.1			**68.4 ± 12.9**		
No (n = 94)	**79.7 ± 14.7**			76.7 ± 10.9			**72.6 ± 9.9**		
Familial characteristics									
ANOVA	Mean ± SD			Mean ± SD			Mean ± SD		
Mother's educational level		**.001**			.16			**.01**	
Elementary/High School (n = 67)	**71.9 ± 16.2**			72.8 ± 11.9			**68.0 ± 11.7**		
University (n = 121)	**78.6 ± 15.4**			76.3 ± 12.8			**72.4 ± 11.4**		
Father's educational level		**.002**			.98			.76	
Elementary/High School (n = 88)	**73.7 ± 15.1**			75.2 ± 11.5			70.8 ± 11.9		
University (n = 95)	**79.2 ± 16**			75.2 ± 13.5			71.3 ± 11.5		
SES		**.002**	High≠ low		.24			.21	
High (n = 65)	**81.1 ± 15.7**			77.2 ± 13.3			73.0 ± 11.7		
Middle (n = 46)	**77.1 ± 15.8**			74.2 ± 11.2			69.7 ± 11.0		
Low (n = 77)	**71.6 ± 15.2**			73.8 ± 12.7			69.9 ± 11.5		
Family status		**.04**			.21			**.04**	
Parents live together (n = 142)	**77.4 ± 15.8**			75.5 ± 12.3			**71.6 ± 11.2**		
Parents do not live together (n = 48)	**71.9 ± 16.4**			73.0 ± 13.4			**67.7 ± 13.1**		
SPEARMAN CORRELATIONS	rho			Rho			rho		
Mother age (n = 212)	−.04	.57		−.04	.52		−.08	.22	
Father age (n = 209)	.00	.95		−.07	.29		−.07	.28	
Number of siblings (n = 241)	**−.13**	**.04**		−.10	.13		**−.18**	**.01**	

Data are given in mean (±SD) or Spearman's rho.
Significant results: p < .05.
SS means Standard score. CSS means Calibrated Severity Score.

that children without ID had better adaptive trajectories (Darrou et al., 2010; Szatmari et al., 2015). Nevertheless, clinicians need to provide age-appropriate interventions for people with ASD and without ID, who also need support to adapt socially in emotional relationships or take responsibility for their own health (Cheak-Zamora et al., 2019; Rock and Becker, 2021). In contrast, we found a weak association between ASD severity and adaptive skills in both young and latency age children (Frost et al., 2017; Liss et al., 2001; Perry et al., 2009). A strong and negative association between ASD severity and AB for communication and socialization was observed only for adolescents. It can be supposed that it was the consequence of the effect of less commonly available early intensive interventions and supports for older adolescents compared to the younger children. The increase in social constraints with age, may also explain our result of an association between ASD severity and socialization skills found in adolescents. In our sample, behavioral problems occurrence was negatively associated with adaptive skills, regardless of the age group. This can be interpreted into the light of the finding of better adaptive skills in our sample for children without psychiatric comorbidities as reported by previous studies (Kraper et al., 2017; Scandurra et al., 2019). In our sample, comorbidity type and child's age influenced this association. For young children and adolescents, affective problems were comorbidities with the greatest negative impact on adaptive skills. This implies promoting interventions focusing on socio-affective dimension, such as parent-mediated social communication therapy (Aldred and Green, 2019). The association described in the literature between higher language skills during childhood and better AB was contrasted in our sample. Early language skills were positively related to all areas of AB for children but not for adolescents. Relations between language skills and AB were also found for young children, which should be interpreted with caution due to the lack of precision in language assessment at this stage. In agreement with other studies, motor skills were positively associated in our sample with daily living skills regardless of age group (Bremer and Cairney, 2018; MacDonald et al., 2013). A recent longitudinal study (Travers et al., 2017) highlighted that motor skills were associated to AB beyond adolescence, with an increasing negative impact of motor difficulties on daily skills until adulthood, which implies specific support over time.

In our sample, children receiving special interventions had overall lower AB than those who did not. Longitudinal studies are needed, as some studies showed that children who received specialized interventions had positive adaptive trajectories (Baghdadli et al., 2012; Bal et al., 2015; Remington et al., 2007). Also, young children and

Table 4
Association between interventions, clinical and familial characteristics and the three VABS-II scores in adolescents.

	Communication		Daily Living Skills		Socialization	
	SS	pvalue	SS	pvalue	SS	pvalue
Clinical characteristics						
ANOVA	Mean ± SD		Mean ± SD		Mean ± SD	
Gender		.67		.91		.57
Boys (n = 54)	71.4 ± 13.3		68.1 ± 12.6		62.9 ± 10.1	
Girls (n = 8)	72.1 ± 6.7		68.6 ± 6.9		65.1 ± 9.5	
Psychiatric comorbidities (CBCL)						
Affective problems		.09		.07		**.04**
Borderline/ clinical (n = 28)	68.0 ± 10.8		64.5 ± 10.8		**60.9 ± 9.7**	
Normal range (n = 11)	76.6 ± 11.0		73.0 ± 13.3		**67.0 ± 6.5**	
Anxiety problems		.09		.48		.71
Borderline/ clinical (n = 30)	72.1 ± 9.2		68.3 ± 11.4		62.9 ± 9.5	
Normal range (n = 9)	64.8 ± 16.3		62.4 ± 13.6		61.6 ± 9.0	
ADHD		.98		.34		.98
Borderline/ clinical (n = 14)	71.8 ± 11.2		70.9 ± 13.7		62.6 ± 10.4	
Normal range (n = 25)	69.6 ± 11.7		64.7 ± 10.6		62.6 ± 8.9	
Oppositional problems		.88		.78		.59
Borderline/ clinical (n = 11)	70.7 ± 10.5		67.7 ± 13.3		61.3 ± 10.9	
Normal range (n = 28)	70.3 ± 11.9		66.6 ± 11.7		63.1 ± 8.7	
Somatic problems		.86		.42		.86
Borderline/ clinical (n = 12)	69.9 ± 5.9		64.7 ± 7.9		63.0 ± 8.3	
Normal range (n = 27)	70.6 ± 13.3		67.9 ± 13.5		62.4 ± 9.8	
Conduct problems		.88		.78		.59
Borderline/ clinical (n = 11)	70.7 ± 10.5		67.7 ± 13.3		61.3 ± 10.9	
Normal range (n = 28)	70.3 ± 11.9		66.6 ± 11.7		63.1 ± 8.7	
Motor skills (M-ABC)		**.002**		**.04**	63.2 ± 8.6	.19
Clinical (n = 28)	**71.4 ± 9.0**		**67.8 ± 10.2**		67.8 ± 8.3	
Normal range (n = 8)	**85.3 ± 13.7**		**72.0 ± 4.0**			
SPEARMAN CORRELATIONS	rho		rho		rho	
Age at diagnosis (19)	−.05	.84	.23	.34	−.03	.89
IQ (n = 62)	**.61**	**<.001**	**.52**	**<.001**	**.47**	**<.001**
ASD symptom severity (ADOS-2 CSS) (n = 51)	**−.39**	**.01**	−.26	.07	**−.46**	**<.001**
Language: EVIP (n = 29)	**.81**	**<.001**	**.54**	**.002**	**.59**	**<.001**
Challenging behaviors (ABC) (n = 41)						
Irritability	**−.36**	**.02**	**−.32**	**.04**	**−.42**	**.01**
Lethargy/ withdrawal	**−.43**	**.01**	**−.56**	**<.001**	**−.47**	**.002**
Stereotypy	**−.46**	**.003**	**−.39**	**.01**	**−.46**	**.003**
Hyperactivity	**−.38**	**.01**	−.21	.18	**−.40**	**.01**
Schooling and interventions						
ANOVA	Mean ± SD		Mean ± SD		Mean ± SD	
Specialized institutions		.52		**.03**		**.04**
Yes (n = 20)	70.1 ± 17.1		**64.3 ± 13.5**		**59.2 ± 10.2**	
No (n = 22)	72.7 ± 7.9		**70.6 ± 9.4**		**65.1 ± 8.2**	
Familial characteristics						
ANOVA	Mean ± SD		Mean ± SD		Mean ± SD	
Mother's educational level		**.04**		**<.001**		**.03**
Elementary/High School (n = 19)	**67.3 ± 13.7**		**61.9 ± 12.6**		**58.8 ± 9.8**	
University (n = 23)	**74.8 ± 11.5**		**72.3 ± 8.9**		**65.2 ± 8.4**	
Father's educational level		.13		**.02**		.22
Elementary/High School (n = 21)	68.8 ± 15.0		**63.4 ± 10.7**		60.8 ± 11.0	
University (n = 19)	74.3 ± 10.3		**72.9 ± 11.6**		64.6 ± 7.7	
SES		.45		.15		.26
High (n = 15)	73.4 ± 7.8		70.3 ± 10.6		62.8 ± 8.1	
Middle (n = 14)	72.9 ± 9.8		68.9 ± 7.3		64.9 ± 10.5	
Low (n = 13)	67.6 ± 19.4		63.1 ± 16.0		58.9 ± 9.6	
Family status		**.01**		**.02**		.24
Parents live together (n = 33)	**69.5 ± 13.4**		**65.5 ± 11.0**		61.4 ± 10.0	
Parents do not live together (n = 9)	**78.6 ± 8.6**		**75.3 ± 12.0**		65.7 ± 6.7	
SPEARMAN CORRELATIONS	rho		rho		rho	
Mother age (n = 46)	.15	.31	.26	.09	**.32**	**.03**
Father age (n = 44)	−.28	.07	−.13	.40	−.14	.38
Number of siblings (n = 56)	−.12	.36	.08	.56	.03	.84

Data are given in mean (±SD) or Spearman's rho.
Other associations with VABS-II scores were performed but are not presented due to the lack of statistical power: ADI-R, schooling.
Significant results: p < .05.
SS means Standard score. CSS means Calibrated Severity Score.

children attending regular or special class mostly had better AB than those out of school, in agreement with Rattaz et al. study (2020), which also underlined the influence of school attendance on psychiatric disorders such as anxiety. This result implies the use of supports and interventions targeting AB from the earliest years of life in order to promote school inclusion in children with ASD.

In our sample children with ASD who had higher communication and socialization skills, regardless of age group, had parents with higher educational levels, as previously described (Ibrahim, 2020). In adolescents, daily living skills were also associated with higher mothers' educational level. It can be assumed that parents with higher educational level also have better material and educational resources to support their children at home towards better adaptation outcomes. In our sample, communication skills were positively correlated with SES both in young children and latency age children. However, daily living skills and socialization were strongly and positively associated with SES only in young children, supporting previous findings that children from lower

SES families were at risk for weaker AB and mostly in early age (Aishworiya et al., 2021). Consequently, there is a challenge to promote access to care and education for children from socially deprived families. In our sample, the parental age at diagnosis was not related to the children's AB, except for adolescents, where socialization skills were positively related to mothers' age. This result is in contradiction with literature where higher parental age was a risk factor for ASD incidence and severity (Idring et al., 2014; Lyall et al., 2020; Sandin et al., 2016; Wu et al., 2017). Higher AB were found in families where children were living with two parents notably for young children and latency age children, the contrary was found in adolescents. We suppose that the parental support for developing daily AB is promising notably in the early development.

This study focused on a descriptive analysis of clinical, interventional and familial characteristics associated to AB. A future research should study the potential association between these different characteristics.

4.1. Strengths and limitations

The present study needs to be considered in the context of number of limitations in interpreting the results. First, even though the ELENA cohort represents a multiregional sample it is not necessarily a nationally representative sample. On the other hand, the study involved a large number of children and adolescents with confirmed multidisciplinary diagnosis of ASD. Second, some clinical data were collected from online parental questionnaires and not from direct examination. On contrary, the study collects a large set of variables measured with standardized and validated instruments. Third, the size of the adolescents group was small and involved a predominantly male composition which limits the generalization of the results. The inclusion of the adolescent's sample however is also a strength in emphasizing possible age, period, and cohort effects that can be present in distinctive ways which change over time. This may be reflected in terms of older age of adolescents (age effect), but they may also reflect different lower experience of intervention and support salient a decade earlier compared to the younger children (cohort effect). Further longitudinal studies are needed to examine adaptive trajectories.

5. Conclusion and implications

The current study of 875 children with ASD suggests that adaptive skills are delayed compared to typical development and related to some clinical characteristics according to age group. IQ and behavioral problems are associated with adaptive skills regardless of age. Also, the higher parents' socio-economic and educational levels are associated with better adaptive skills. This result draws attention to the most vulnerable families. Schooling is additionally associated with better AB underscoring the need for school-based educational interventions that target improvement in all dimensions of adaptive skills.

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Ethical approval

The ELENA cohort study was approved by the South Mediterranean Ethics Committee on the Research of Human Subjects of Marseille (ID RCB: 2014-A01423-44) and the National Commission for Computing and Liberties (CNIL. number DR-2015-393).

Availability of data and material

Research data are not shared due to the need for confidentiality. The corresponding author, Pr Amaria Baghdadli, confirms that she had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Authors' contributions

Ela Miniarikova: Conceptualization, Validation, Writing - Original Draft, Writing - Review & Editing. Lee Audras-Torrent: Conceptualization, Validation, Writing - Original Draft, Writing - Review & Editing. Mathilde Berard: Conceptualization, Validation, Writing - Original Draft, Writing - Review & Editing. Marianne Peries: Methodology, Software, Formal analysis, Writing - Review & Editing. Marie-Christine Picot: Methodology, Writing - Review & Editing. Kerim Munir: Writing - Review & Editing. Amaria Baghdadli: Writing - Review & Editing, Project administration, Funding acquisition, supervision.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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