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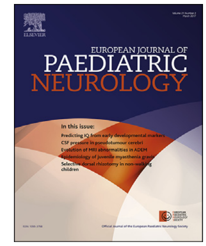

Original article

Do developmental milestones at 4, 8, 12 and 24 months predict IQ at 5–6 years old? Results of the EDEN mother–child cohort

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ABSTRACT

Rationale: The present study aims: (i) to determine how well developmental milestones at 4, 8, 12 and 24 months may predict IQ at 5–6 years old, (ii) to identify cognitive domains during the first two years that best predict later IQ and (iii) to determine whether children with IQ in the normal range at 5–6 years old may differ from disabled (IQ < 70) and gifted children (IQ > 130) with regard to their early cognitive development.

Method: The main developmental milestones were collected through self-administered questionnaires rated by parents at 4, 8, 12 and 24 months and through parental questionnaires administered by a trained interviewer and questionnaires completed following a medical examination at 12 months. These questionnaires were derived from the Brunet-Lézine Psychomotor Development Scale and they addressed several cognitive domains (gross and fine motor skills, language and socialization).

Results: (i) Developmental milestones predict a substantial part of the later IQ variance from 24 months (R^2 ~ 20%). (ii) Early language skills more strongly predict later IQ than the other cognitive domains. (iii) Several cognitive domains, but particularly language skills, predict disabled children at 5–6 years old (from the age of 8 months) and gifted children (from the age of 12 months).

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Discussion: The present study provides valuable information for early developmental assessment and could contribute to a better understanding of intellectual development.

1. Introduction

The extent to which cognitive development during the first two years of life contributes to future intelligence is a central issue for the early identification of children with intellectual disability,[1] as well as for our understanding of intelligence development.

Longitudinal studies have consistently reported that cognitive development before the age of 2 years poorly predicted later cognitive skills.[6,11,19,21] This may reflect both the susceptibility of early cognitive development to a large variety of intrinsic and extrinsic factors, as well as the limitations of the instruments used to probe it (mostly questionnaires evaluating the main developmental milestones). Measures of cognitive development have been found to be progressively more correlated with later measures of cognitive skills and to become strongly correlated from the age of 5 years.[2,8,25,28]

In a recent study, Breeman et al. examined the stability of intelligence test scores in a sample of 260 children born before 32 weeks of amenorrhea and with a birth term less than 1.5 kg (children at risk) and another sample of 229 children born at term.[6] The authors reported that measures of cognitive development at the ages of 5 and 20 months, assessed by the Griffiths Mental Development Scale[13] were poorly correlated with measures of cognitive development at the age of 4 years, assessed by the Columbia Mental Maturity Scale[7] in the sample of children born at term ($r = 0.09$ and $r = 0.32$, respectively). The correlation estimates were higher in a subsample of children at risk without neurological complications ($r = 0.23$ at 5 and $r = 0.46$ at 20 months) and even higher in a subsample of children at risk but with neurological complications ($r = 0.39$ and $r = 0.83$, respectively). These results indicated that cognitive skills during the first two years poorly predicted later cognitive skills in general, but that children born with particular risk factors may have a greater stability of cognitive skills during their development. Whereas children with intellectual disability are known to reach developmental milestones significantly later than children with IQ in the normal range,[29] little is known about the early cognitive development of gifted children.

Surprisingly, no study has, to our knowledge, specifically aimed to identify the cognitive domains (*e.g.*, motor skills, language, attention, memory, socialization, etc.) during the first two years that are the most strongly associated with later IQ. However, such studies could potentially improve the early identification of children with intellectual disability (or those with high-IQ). Moreover, such studies could shed new light on the development of intelligence.

The objectives of this study are:

(*i*) To determine how well developmental milestones at 4, 8, 12 and 24 months may predict IQ at the end of the preschool period (5–6 years old).
(*ii*) To identify the cognitive domains during the first two years that most strongly predict IQ at 5–6 years old.
(*iii*) To determine whether children with IQ in the normal range at 5–6 years old may differ from disabled (IQ < 70) and gifted children (IQ > 130) with regard to their cognitive development at 4, 8, 12 and 24 months.

2. Methods

2.1. Participants

In the present study, we used data from a large population-based sample of French children from the EDEN prospective mother–child cohort study.[15] The primary aim of the EDEN cohort was to identify prenatal and early postnatal nutritional, environmental and social determinants associated with children's health and their normal and pathological development. Pregnant women seen during a prenatal visit at the departments of Obstetrics and Gynecology of the French University Hospitals of Nancy and Poitiers before their twenty-fourth week of amenorrhea were invited to participate. Exclusion criteria included a history of diabetes, twin pregnancies, intention to deliver outside the university hospital or to move out of the study region within the next 3 years, and inability to speak French. The participation rate among eligible women was 53%. Enrollment started in February 2003 in Poitiers and in September 2003 in Nancy, lasted for 27 months in each center and resulted in the inclusion of 2002 pregnant women (Fig. 1). The study was approved by the Ethical Research Committee (Comité consultatif de protection des personnes dans la recherche biomédicale) of Bicêtre Hospital and by the Data Protection Authority (Commission Nationale de l'Informatique et des Libertés). Informed written consents were obtained from parents for themselves at the time of enrollment and for the newborn after delivery.

2.2. Measures

2.2.1. *Cognitive development at 4, 8, 12 and 24 months*

The main developmental milestones were collected through self-administered questionnaires to parents at 4, 8, 12 and 24 months and through parental questionnaires administered by a trained interviewer and questionnaires completed following a medical examination at 12 months. These questionnaires were derived from the Brunet-Lézine Psychomotor Development Scale (Brunet-Lézine-derived scale). This scale is widely used in France (by both clinicians and researchers[12]) to assess cognitive development during the first two years. It has been validated on a sample of 1032 French children between 1994 and 1996.[16] Questions were in the form "does your child do X?" with only yes/no responses (see Supplementary Tables 1, 2 and 3). In total, there were 14 questions asked at 4 months (answered by parents), 29 questions at 8 months (answered by parents), 53 questions at 12 months (14 answered by parents, 29 administered by a trained interviewer to parents and 10 answered by a clinician) and 37 questions at 24 months (answered by parents). These questions were grouped into two cognitive domains at 4 months (motor skills and Socialization/Communication) and four cognitive domains at 8, 12 and 24 months (gross motor skills, fine motor skills, language and socialization). For each cognitive domain, scores were calculated as the sum of all questions corresponding to the cognitive domain. Each score was then converted into a z-score. As most of these scores had a ceiling effect, distributions were negatively skewed (mean skewness value = −0.56 [SD = 0.50]).

2.2.2. *MacArthur-Bates Communicative Development Inventory [CDI-2]*

At 24 months of age, parents completed the short French version of the MacArthur-Bates Communicative Development Inventory [CDI-2].[18,17,22] Parents were asked to indicate which words from a list of 100 their child could say spontaneously (expressive vocabulary). Scores are the number of words produced by the child. The psychometric properties of the short French version of the MacArthur-Bates Communicative Development Inventory at 24 months have been analyzed by Kern et al.,[18] showing high test–retest reliability and strong associations with the corresponding scores from the complete version.

2.2.3. *IQ at age 5–6 years old*

At the age 5–6 years old (mean age = 67.9 months; SD = 1.8), 1100 children were assessed using the Wechsler Preschool and Primary Scale of Intelligence 3rd Edition (WPPSI-III[30]; using French norms). Children with a FSIQ score strictly higher than 130 were considered as gifted and those with a FSIQ strictly lower than 70 as disabled.[23] Verbal and Performance IQ were available.

2.3. *Data analysis*

Cognitive domain scores of the Brunet-Lézine-derived scale were calculated if less than half of the questions were missing. Missing questions were imputed by the mean of the question in the sample.

First, linear regression models were used to determine how well each question of the Brunet-Lézine-derived scale and each cognitive domain at 4, 8, 12 and 24 months predicted IQ at 5–6 years old. Univariate and multivariable linear regression models were performed at 4, 8, 12 and 24 months separately with FSIQ as dependent variable and cognitive domains as independent variables: *(i)* motor skills and Socialization/Communication scores at 4 months, *(ii)* gross motor skills, fine motor skills, language and socialization at 8 and 12 months, and *(iii)* these four cognitive domains and CDI-2 at 24 months. Special attention was paid to the part of the IQ variance explained by each cognitive domain in multivariable linear regression models (*i.e.*, the coefficient of determination (R^2)). The same models were also performed separately with Performance IQ and Verbal IQ of the WPPSI-III as dependent variables (Supplementary Tables 4 and 5). IQ scores (FSIQ, Performance IQ and Verbal IQ) were converted into a z-score for interpreting effect sizes.

Then, logistic regressions were used to determine the accuracy (*i.e.*, Area Under the ROC Curve [AUC]) of each cognitive domain to correctly predict later cognitive status; *i.e.*, children with normal IQ *versus* disabled children (IQ < 70) and gifted children (IQ > 130) *versus* children with normal IQ. The measures of the AUC is a measure of how well a score can distinguish between two groups, with an AUC of 1 representing perfect classification and an AUC of 0.5 indicating a random result.

All statistical analyses were performed using SAS 9.2 software (SAS Institute, Cary, NC).

3. Results

Among the 2002 women included in the EDEN study, 1907 mother–child pairs were still in the cohort at the time of delivery[15] (Fig. 1). In this longitudinal study, the attrition rate at 5–6 years old was 39%. Analyses were conducted on 1100 children who were assessed with neuropsychological tests at 5–6 years old (Table 1). We identified 19 children (1.7%) whose FSIQ was <70, and 23 (2.1%) children whose FSIQ was >130. Supplementary Fig. 1 shows the distribution of FSIQ scores in the EDEN mother–child cohort (N = 1100; mean = 103.0; standard deviation = 13.6). Compared to children who were not assessed with neuropsychological tests at 5–6 years old, the children included in our analyses significantly differed with higher parental educational level ($p < 0.001$) and family income ($p < 0.001$).

Four percent of the questions were missing at 4 months, 4.6% at 8 months, 2.5% [rated by interviewers] to 6.3% [rated by parents] at 12 months and 10.5% at 24 months. Children with missing scores at one time point were not necessarily those with missing scores at a later time (*e.g.* among the children with missing data at 4 months, 45.1% had completed data at 8 months). 10.6% of the CDI-2 was missing.

Table 2 shows the univariate and multivariable linear regression models with FSIQ as dependent variable and the cognitive domains at each time point as independent variables. At 4, 8 and 12 months, the set of cognitive domain explained a small part of the IQ variance at 5–6 years old, increasing with the age of the developmental assessment (R^2 = 1.2%, 2.8% and 7.0%, respectively). At 24 months, cognitive domains predicted a substantial part of the later IQ variance (R^2 = 18.9%). Despite a positively skewed distribution of most of the cognitive domain scores of the Brunet-Lézine-derived scale, the residuals of the univariate and multivariable linear models tended to be normally distributed and, thus, appropriate to interpret regression parameters.

Similar results were found when separately examining each question of the Brunet-Lézine-derived scale (Supplementary Tables 1–3). On average, children who had

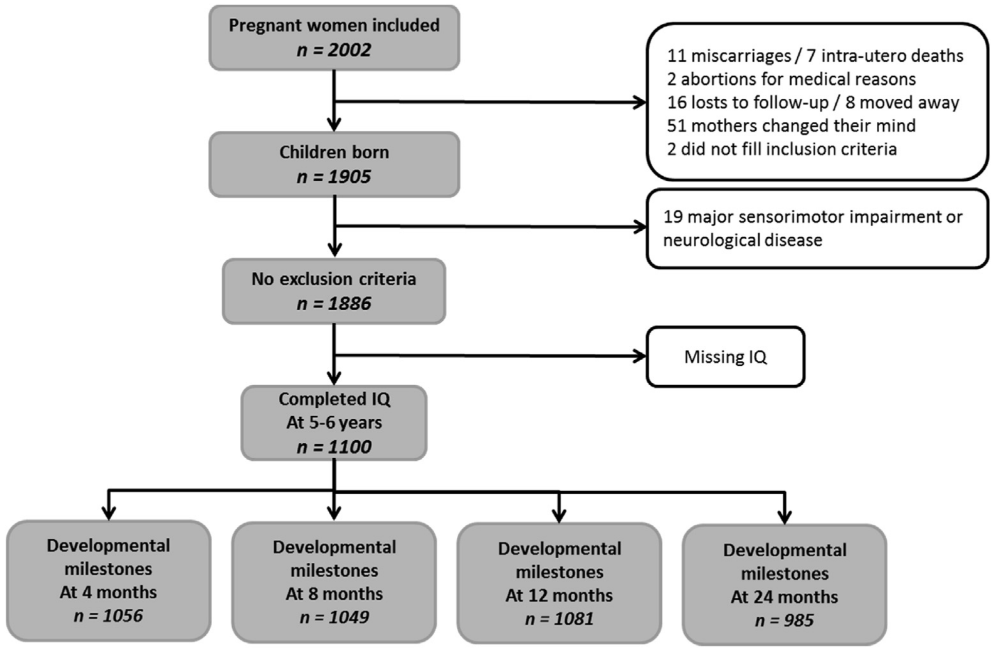

Fig. 1 – Flowchart.

not reached a developmental milestone acquired by 90% of the children of the same age scored 2.5 IQ points lower when milestones were assessed at 4 and 8 months, 5 IQ points lower when assessed at 12 months and 8 IQ points lower when assessed at 24 months. Fig. 2 shows that, the greater the proportion of children who reached a given developmental milestone, the larger the IQ difference between those who reached that milestone and those who did not. Furthermore, this relationship increased with the age at which the milestones were assessed, consistent with the increase in predictive power with age.

Comparisons of β values in Table 2 allow one to assess the relative predictive value of different cognitive domains. At 12 months β (language skills) = 0.18 (SD = 0.03), β (gross motor

Table 1 – Perinatal and demographic characteristics in children defined as disabled, normal or gifted according to IQ at 5–6 years (N = 1100).

	Disabled children IQ < 70 n = 19	Children with normal IQ 70 ≤ IQ ≤ 130 n = 1058	Gifted children IQ > 130 n = 23	Disabled children vs Children with normal IQ p-value	Gifted children vs Children with normal IQ p-value
Perinatal and demographic characteristics					
Male, %	79.0	52.8	47.8	0.028	0.600
Alcohol during pregnancy (drinks/week)	0.9 (1.5)	0.6 (1.4)	0.5 (1.0)	0.435	0.748
Tobacco consumption during pregnancy, %	16.7	22.7	4.4	0.305	0.071
Ever breastfed, %	63.2	72.8	87.0	0.641	0.146
Parental education (years)	12.3 (2.2)	13.5 (2.3)	14.6 (2.1)	0.070	0.027
Household income (k€)	2.2 (1.0)	2.7 (1.0)	3.1 (0.8)	0.048	0.097
Maternal age at birth of child (years)	28.8 (4.7)	29.7 (4.8)	29.3 (4.8)	0.591	0.705
Number of older siblings	0.6 (0.7)	0.8 (0.9)	0.5 (0.8)	0.505	0.106
Gestational age (weeks)	38.4 (2.1)	39.3 (1.7)	39.3 (2.5)	0.036	0.932
Birth weight (kg)	3.2 (0.7)	3.3 (0.5)	3.3 (0.5)	0.837	0.985
Recruitment center (Nancy)	21.1	41.4	82.6	0.056	<0.001
IQ at 5–6 years old					
FSIQ	59.7 (9.1)	103.1 (11.6)	134.6 (3.1)	**<0.001**	**<0.001**
Verbal IQ	70.6 (12.7)	106.7 (12.9)	132.7 (8.3)	**<0.001**	**<0.001**
Performance IQ	62.7 (10.3)	99.3 (12.4)	128.1 (9.2)	**<0.001**	**<0.001**
CDI-2	22.3 (25.2)	61.3 (29.2)	81.1 (27.3)	**<0.001**	**0.002**

In bold $p < 0.05$.

Table 2 – Prediction of FSIQ at 5–6 years old by cognitive domain at 4, 8, 12 and 24 months of the Brunet-Lézine-derived scale and CDI-2 (converted into z-score).

Brunet-Lézine-derived scale scores	Univariate					Multivariable[a]					Multivariable[b]				
	N	β	SD	p-value	R^2 (%)	N	β	SD	p-value	R^2 (%)	N	β	SD	p-value	R^2 (%)
4 months						1056				1.2					
Gross and fine motor skills	1056	**0.08**	**0.03**	**0.0118**	0.6		0.03	0.03	0.286		–	–	–	–	
Socialization/Communication	1056	**0.11**	**0.03**	**<0.001**	1.1		**0.09**	**0.03**	**0.009**		–	–	–	–	
8 months						1049				2.8					
Gross motor skills	1049	**0.09**	**0.03**	**0.003**	0.8		**0.06**	**0.03**	**0.048**		–	–	–	–	
Fine motor skills	1049	**0.11**	**0.03**	**<0.001**	1.2		**0.09**	**0.03**	**0.005**		–	–	–	–	
Language	1049	**0.11**	**0.03**	**<0.001**	1.1		**0.09**	**0.03**	**0.006**		–	–	–	–	
Socialization	1049	−0.03	0.03	0.328	0.1		**−0.09**	**0.03**	**0.007**		–	–	–	–	
12 months						1024				7.0					
Gross motor skills	1074	**0.16**	**0.03**	**<0.001**	2.9		**0.10**	**0.03**	**0.002**		–	–	–	–	
Fine motor skills	1081	**0.08**	**0.03**	**0.008**	0.6		0.00	0.03	0.966		–	–	–	–	
Language	1081	**0.22**	**0.03**	**<0.001**	5.1		**0.18**	**0.03**	**<0.001**		–	–	–	–	
Socialization	1031	**0.17**	**0.03**	**<0.001**	3.1		**0.07**	**0.03**	**0.035**		–	–	–	–	
24 months						985				18.9	982				20.5
Gross motor skills	985	**0.17**	**0.03**	**<0.001**	3.1		**0.07**	**0.03**	**0.018**			**0.07**	**0.03**	**0.027**	
Fine motor skills	985	**0.18**	**0.03**	**<0.001**	3.3		0.03	0.03	0.311			0.03	0.03	0.320	
Language	985	**0.42**	**0.03**	**<0.001**	18.1		**0.43**	**0.04**	**<0.001**			**0.26**	**0.06**	**<0.001**	
Socialization	985	**0.29**	**0.03**	**<0.001**	8.2		−0.04	0.04	0.290			−0.07	0.04	0.104	
CDI-2	983	**0.42**	**0.03**	**<0.001**	17.8	–	–	–	–			**0.22**	**0.05**	**<0.001**	

In bold $p < 0.05$.
Each score (FSIQ, Brunet-Lézine-derived scale scores, CDI-2) was converted into a z-score.
[a] Models were performed at 4, 8, 12 and 24 months separately with FSIQ as dependent variable and cognitive domains as independent variables.
[b] The model was performed with FSIQ as dependent variable and the four cognitive domains at 24 months and CDI-2 at 24 months as independent variables.

skills) = 0.10 (SD = 0.03) and β (socialization) = 0.07 (SD = 0.03). At 24 months β (language skills) = 0.43 (SD = 0.04) and β (gross motor skills) = 0.07 (SD = 0.03). Thus, language skills are the cognitive domain that most strongly predicts IQ at 5–6 years old. When the CDI-2 score was included in the multivariable linear regression model at 24 months (2nd multivariable model in Table 2), the language skills score of the Brunet-Lézine-derived scale remained significantly associated with IQ at 5–6 years old. This suggests that questions in the Brunet-Lézine scale captured a broad range of language skills whose

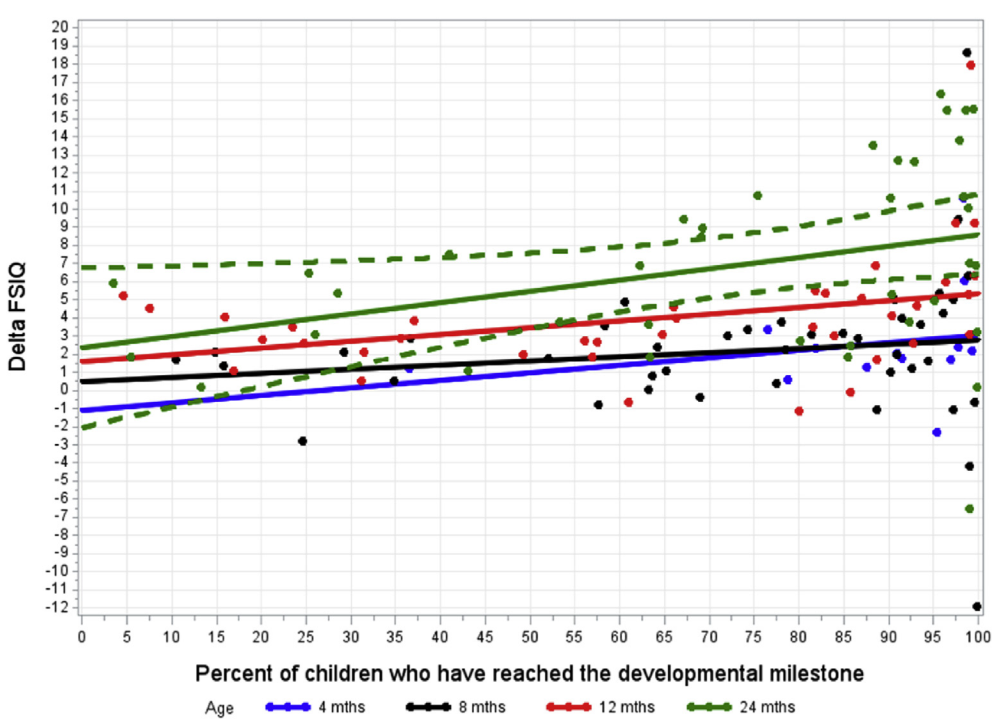

Fig. 2 – Relationship between delta FSIQ (difference of FSIQ between children who have reached the developmental milestone and those who have not) and percentage of children who reached the developmental milestone.

predictive value reaches beyond that of the expressive vocabulary skills measured in the CDI-2.

Table 3 shows the predictive accuracy of each cognitive domain with respect to cognitive status (children with normal IQ *versus* disabled children and gifted children). Language and fine motor skills at 8 months predicted disabled children at 5–6 years old but none of the cognitive domain at 8 months predict gifted children at 5–6 years old. Language, gross motor and fine motor skills at 12 months predicted disabled children at 5–6 years old but only language skills at 12 months predicted gifted children at 5–6 years old. All cognitive domains at 24 months predicted disabled children at 5–6 years old and language skills were the most discriminatory cognitive domain. Only language skills and socialization at 24 months predicted gifted children at 5–6 years old.

4. Discussion

Developmental milestones at 4, 8 and 12 months predict a small part of the IQ variance at age 5–6 years, but milestones at 24 months predict a substantial part of the later IQ variance (R^2 ~ 20%). Early language skills more strongly predict later IQ than the other cognitive domains. Finally, several developmental milestones, in particular concerning language skills, predict children with IQ lower than 70 at 5–6 years old (from the age of 8 months) and gifted children (with IQ greater than 130) (from the age of 12 months).

In line with results of previous studies,[6,11,19,21] we found that developmental milestones predict a substantial part of the later IQ variance from 24 months. The low predictive power of milestones before 24 months may be interpreted as showing a poor stability of early cognitive development, possibly related to the influence of environmental factors during this period and early interventions. However, this could also be explained by the psychometric limitations of the instruments used to measure development during this period. These scales (*e.g.* the Bayley Scales of Infant Development[3] or the Brunet-Lézine Psychomotor Development Scale) measure more perceptual and motor skills than skills targeted by IQ tests: *i.e.*, reasoning skills, verbal and nonverbal problem-solving skills, *etc.*[5,27] Moreover, the type of instrument should also be considered when interpreting correlation (or R^2) values. Indeed, cognitive development during the first two years was assessed mainly by questionnaires (completed by parents or clinicians), while later cognitive development was assessed mainly by neuropsychological tests. It has been proposed that early electroencephalographic (EEG) measures might provide greater insights into later developmental outcomes.[14,20] However, it remains to be properly evaluated how these measures are reliable and predictive.[24]

Language skills at 12 and 24 months more strongly predicted later IQ scores than the other cognitive domains. However, the Brunet-Lézine-derived scale does not measure all cognitive domains exhaustively. Other cognitive domains, such as attention, memory, visual information processing skills[26] or reaction times[9] might have also contributed to the prediction of later IQ. We found that language skill scores of the Brunet-Lézine-derived scale remain strongly ($\beta = 0.26$) associated with IQ at 5–6 years old, independently of expressive vocabulary skills (measured by the CDI-2). Indeed, it is remarkable that a set of a dozen questions about language skills at 24 months predicts a similar part of the later IQ variance than a 100-word check-list. Moreover,

Table 3 – AUC values of cognitive domains at 4, 8, 12 and 24 months of the Brunet-Lézine Psychomotor Development Scale to predict later cognitive status: (1) children with normal IQ *versus* disabled children (IQ < 70), and (2) gifted children (IQ > 130) *versus* children with normal IQ.

Brunet-Lézine-derived scale scores	Children with normal IQ *versus* Disabled children (IQ < 70)					Gifted children (IQ > 130) *versus* Children with normal IQ				
	N	AUC	IC 95%		p-value	N	AUC	IC 95%		p-value
4 months										
Gross and fine motor skills	1034	0.51	0.39	0.63	0.401	1038	0.56	0.47	0.67	0.507
Socialization/Communication	1034	0.60	0.45	0.75	0.163	1038	0.54	0.42	0.67	0.370
8 months										
Gross motor skills	1026	0.61	0.47	0.75	0.162	1031	0.46	0.34	0.58	0.426
Fine motor skills	1026	0.63	0.51	0.75	0.021	1031	0.40	0.30	0.51	0.135
Language	1026	0.66	0.53	0.79	0.010	1031	0.52	0.42	0.62	0.432
Socialization	1026	0.52	0.40	0.64	0.942	1031	0.49	0.38	0.60	0.601
12 months										
Gross motor skills	1052	0.75	0.63	0.87	<0.001	1056	0.58	0.46	0.701	0.206
Fine motor skills	1059	0.52	0.37	0.68	0.539	1063	0.60	0.48	0.71	0.119
Language	1059	0.78	0.65	0.91	<0.001	1063	0.67	0.55	0.78	0.011
Socialization	1010	0.70	0.58	0.81	0.010	1016	0.63	0.50	0.76	0.102
24 months										
Gross motor skills	962	0.78	0.66	0.91	<0.001	969	0.52	0.40	0.65	0.644
Fine motor skills	962	0.77	0.66	0.87	<0.001	969	0.60	0.48	0.72	0.082
Language	962	0.88	0.78	0.97	<0.001	969	0.71	0.59	0.82	0.011
Socialization	962	0.73	0.61	0.84	0.003	969	0.67	0.57	0.77	0.006
CDI-2	960	0.85	0.74	0.96	<0.001	967	0.74	0.61	0.86	0.002

In bold: $p < 0.05$.
Each score (Brunet-Lézine-derived scale scores, CDI-2) was converted into a z-score.

supplementary analysis revealed that early language skills more strongly predicted both later Performance IQ and Verbal IQ of the WPPSI-III (Supplementary Tables 4 and 5). These results suggest that questions of the Brunet-Lézine-derived scale in the language domain were those that best target the construct of general intelligence.

From the age of 8 months, several cognitive domains (and particularly language skills) predict intellectual disability at 5–6 years old. The mean predictive accuracies of our set of cognitive domains were small at 8 months (AUC ~ 0.60), moderate at 12 months (AUC ~ 0.70) and high at 24 months (AUC ~ 0.80). These findings are consistent with results of previous studies.[6,11,19,21] From the age of 12 months, several cognitive domains, and also particularly language skills, predict giftedness, but to a lesser extent than intellectual disability at 5–6 years old (mean AUC at 12 months = 0.62 and 0.85 at 24 months). The fact that the Brunet-Lézine-derived scale is most predictive of developmental delays is consistent with its primary function as a pediatric instrument. However it may not have been entirely designed and optimized for that purpose. Indeed, we have found that, the greater the proportion of children who pass a given milestone, the more not passing this milestone is informative of later IQ. In the Brunet-Lézine-derived scale as a whole, the mean percentage of children who have reached the developmental milestones is 68.4%, with the 1st quartile at 52.0% and the 4th quartile at 92.3%. Therefore this instrument is better suited to detect developmental delays, but could be further improved for that purpose. If, on the contrary, the primary goal was to predict giftedness, most of the items should be passed by only a minority of children. Because there were too few items with a low success rate in the present version, this strategy cannot be assessed using the current data. If one were to further investigate this question, one possibility would be to administer the same items at an earlier age, in order to be more sensitive to children who are ahead in development. Finally, if the primary goal was to best predict the full range of IQ scores, the best strategy would be to include, at each age, items that span the whole range of developmental time-courses, some passed by almost all children, some passed by about half of them, and some passed by a minority only, as usually done in psychometrics.

These results should be interpreted in the light of the selection bias. Compared to the National Perinatal Survey (ENP) carried out among 14,482 women who delivered in France in 2003,[4] women participating in the EDEN study had similar sociodemographic characteristics except they had higher educational background (53.6% had a high-school diploma *versus* 42.6% in the ENP survey) and were more often employed (73.1% were employed during pregnancy cohort *versus* 66.0% in the ENP survey).[10,15] Moreover, compared to children who were not assessed with neuropsychological tests at 5–6 years old in the EDEN study, those included in our analyses also had a higher socioeconomic status. These selection bias may contribute to lower variability in our data (standard deviation of FSIQ = 13.6 *versus* 15 in the general population). Consistently, IQ scores were higher in our sample than in the general population (mean of FSIQ = 103.0 *versus* 100 in the general population) and there were fewer children with IQ < 70 (1.7%) than expected (2.5%). Finally, we adopted an inclusive strategy of single imputation of missing data, which may lead to lower variability of our measures of cognitive skills at 4, 8, 12 and 24 months.

5. Conclusion

The present study provides valuable information regarding the assessment of early cognitive development. The version of the Brunet-Lézine Psychomotor Development Scale used in the EDEN study moderately predicted later IQ at age 5–6, at least when administered around 24 months. Earlier milestones were much less informative. Developmental milestones in the language domain were those that best predict the construct of general intelligence. Finally, this instrument was best suited to detecting developmental delays. However, we have also suggested ways in which it might be adapted to serve different purposes, such as predicting giftedness.

Conflict of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ejpn.2016.11.001.

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