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ORIGINAL RESEARCH

# Leiter-R versus developmental quotient for estimating cognitive function in preschoolers with pervasive developmental disorders



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**Abstract:** The utility of the developmental quotient (DQ) obtained with the Psychoeducational Profile Revised (PEP-R) was assessed as a means of estimating cognitive ability in young children with pervasive developmental disorders. Data from the PEP-R were analysed in a sample of 44 children aged from 2.0 to 5.9 years (mean 3.46 ± 1), 13 with an autistic disorder and 31 with a pervasive developmental disorder not otherwise specified. DQ scores were compared with scores from the Leiter International Performance Scale Revised-Visualization and Reasoning Battery (Leiter-R) in the same 44 children. Overall and domain DQs on the PEP-R were significantly correlated with Leiter-R scores. This study suggests that DQ scores obtained from the PEP-R in preschool children with pervasive developmental disorders may be a viable alternative to the Leiter-R as an assessment tool.

**Keywords:** autism, pervasive development disorder, PEP-R, assessment, cognitive function

## Introduction

It has long been recognized that cognitive impairment is a feature associated with autism. Assessing levels of intelligence in children with pervasive developmental disorders is important to be able to understand their ability, to make a reliable prognosis, to plan remedial education, and as an outcome measure in evaluation of treatment effectiveness.[1,2] Several cognitive functions can be tested using the Wechsler Intelligence Scales,[3,4] the Stanford-Binet Intelligence Scale,[5] and the Mullen Scales of Early Learning.[6] For individuals with autism and poor linguistic levels, the Leiter International Performance Scale[7] can be used.[8] Nevertheless, there is a general consensus that it is more difficult to make a cognitive assessment of younger, low-functioning, and nonverbal children, given their limited social interaction and communication skills.[9–11] Many features and behavioral problems can further interfere with the accurate assessment of a young child's cognitive abilities, including difficulty in holding their attention, overactivity, sensory issues, and poor compliance.[12]

Despite general agreement that cognitive functioning is a critical component of treatment planning, in addition to the clinical need for intelligence quotient (IQ) information, there is no current agreement about the most appropriate test instrument for measurement of cognitive functioning in this population.[13] The Psychoeducational Profile Revised (PEP-R),[14] developed in 1990 from an earlier version of the PEP, represents a useful tool for the assessment of children with pervasive developmental disorders (PDD). The PEP-R offers a developmental approach to the assessment of children with autism or related developmental disorders, and is designed to identify

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idiosyncratic learning patterns. The test provides information on the developmental level in seven important domains and assesses the nature and severity of the disturbed behavior commonly observed in children with PDD, focusing on four areas and yielding an overall qualitative analysis. It is thus useful as both an assessment and a diagnostic tool.[15]

Since it describes the developmental level of several important domains, the PEP-R enables careful planning of intervention within individually tailored educational programs for children, guiding the treatment of children aged between six months and seven years.[16] The revised version of the PEP also makes it possible to assess and to plan educational programs for preschool children because it provides prescholastic items.[15] In addition, the PEP-R has been used as an outcome measure in published studies of treatment effectiveness.[17,18]

Several features make the PEP-R suited to the assessment of behavior and development in children with PDD. The test consists of concrete and interesting material, there is no time pressure, items do not have to be done in a fixed order, only limited verbal skills are necessary, and language items are separate from the general assessment items. Because of these characteristics, the PEP-R can successfully analyse all children, offering the possibility of assessing a wide developmental range.[14] Moreover, a total developmental quotient (DQ) score can be calculated from the PEP-R.

In the present study, the objective was to try to go further than establishing a very general link between "global" cognitive measures, although the validity of attributing PDD children a "general cognitive level" is questionable. DQ scores for the PEP-R were compared with intelligence quotient (IQ) scores for the Leiter International Performance Scale Revised-Visualization and Reasoning Battery (Leiter-R)[19] to evaluate the utility of the PEP-R as a measure for estimating the general cognitive development of preschool children with PDD. The DQ can serve as a measure of the discrepancy between the performance standard according to the chronological age of the child and true developmental functions, being roughly comparable with the Leiter scale, ie, focused on nonverbal abilities. Simple correlation does not allow direct comparisons between levels of cognitive retardation or advances measured by the two scales. Even if a positive correlation is found, it might reflect some common cognitive growth but cannot tell whether they are estimated at an equivalent developmental level. The present comparison may have valid support in clinical practice.

# Methods

## Participants

The sample comprised 44 preschool children (37 males, 7 females), aged 2.0–5.9 years (mean 3.46 ± 1) referred to our department because of disturbances related to autistic spectrum disorders. The diagnoses were made according to the DSM-IV[20] and corroborated by clinical observation and instrumental tests. The cutoff value for autism was verified and applied for the different instruments. All children were tested using a standard battery of assessments consisting of the Childhood Autism Rating Scale[21] and a standardized semistructured interview with the child's caregivers using the Autism Diagnostic Interview-Revised (ADI-R).[22] Administrators of the ADI-R underwent prior training. The ADI-R was completed for 44 patients. The clinical assessment of adaptive and behavioral function was completed using the Vineland Adaptive Behavior Scales.[23]

An autistic disorder (AD) was diagnosed in 13 (29.6%) children aged 2.0–5.9 years (mean age 3.6 ± 1.2) at the time of observation, and PDD not otherwise specified (PDDNOS) in 31 children (70.4%) aged 2.0–5.5 years (mean 3.4 ± 0.9).

Patient characteristics are summarized in Table 1. All diagnoses were made by the same physician with a specific background in PDD assessment. All parents had given consent to conduct this clinical research using diagnostic instruments.

## Procedure

The PEP-R[15] was used to assess 44 children to identify skills and behaviors that could be useful for diagnostic and educational planning goals, and the same children were tested with the Leiter-R to obtain an estimate of cognitive nonverbal functioning. The tools were administered by a child neuropsychiatrist and/or a psychologist, within a few days of each other.

The PEP-R consists of a series of toys, games, objects, and pictures which are offered to the child during structured play sessions. The child's reactions are observed and classified. The version adopted included a developmental scale (131 items) and a behavioral scale (43 items).

The developmental scale explores seven developmental areas (imitation, perception, fine motor, gross motor, eye-hand coordination, cognitive performance, and cognitive verbal). The scoring is classified as a "pass" when the item task is achieved, "emerging" when partially achieved, and "fail" when the child completely fails to achieve the task. A developmental score for each of the developmental areas

**Table 1** ADI-R and CARS scores for the two groups

| Variable | AD children | PDDNOS children |
|---|---|---|
| ADI-R scores (sample) | n = 13 | n = 31 |
| ADI-RSI mean (cutoff for autism = 10) | 16.6 ± 4.3 | 12.5 ± 4.3 |
| ADI-C mean (NVC cutoff for autism = 7; VC cutoff for autism = 8) | 10.2 ± 2.3 | 7.9 ± 2.3 |
| ADI-R-RSB mean (cutoff for autism = 3) | 4.6 ± 1.2 | 3.2 ± 1.3 |
| ADI-R developmental deficit evident before 36 months mean (cutoff for autism = 1) | 3.7 ± 0.7 | 3.5 ± 1.0 |
| CARS mean (cutoff for autism = 30) | 39 ± 4.49 | 30 ± 4.79 |

**Abbreviations:** AD, autism disorder; ADI-R, Autism Diagnostic Interview-Revised; CARS, Childhood Autism Rating Scale; PDDNOS, pervasive developmental disorder not otherwise specified; NVC, nonverbal communication domain; VC, verbal communication domain; RSI, reciprocal social interaction domain; RSB, repetitive and stereotyped behavior domain; C, communication domain.

can be calculated by summing the number of successfully completed items. In this way a developmental profile can be derived. This will show the child's relative strengths and weaknesses in different areas in graph form, indicating the specific developmental level for each of the developmental areas. The developmental level in each area can be compared, providing information on the child's learning patterns, and ability and difficulty in each area. An overall developmental score is calculated by summing all successfully completed items, which can be used to estimate age-equivalent scores. By dividing the child's overall age-equivalent score by his/her chronological age, an overall DQ can be calculated. This value indicates an overall developmental level as compared with the normal development of a typical child.

In addition to the developmental items, the PEP-R also contains a number of behavioral items that measure the severity of AD in children with regard to four areas (affect and development of relationships, materials, sensory modalities, and language). For each item, the behavior is scored as "appropriate" when the behavior is typical for the child's chronological age, "mild" when the behavior is atypical, "severe" for atypical and dysfunctional behaviors of a greater intensity and type than in the previous levels, and "not applicable" is used only for language items that cannot be scored because of the young age of the child or the absence of spoken language.

A behavioral profile can be derived by summing the number of items in each area classified in this way. This profile reveals behavioral problems not shown by the developmental profile, and provides information on the severity of a child's behavioral difficulties. The items on the behavioral scale are not norm-referenced like those on the developmental scale because these particular behaviors are abnormal for children at any age. Therefore, this scale has not only an assessment but also a diagnostic component, enabling behaviors compatible with a diagnosis of AD to be identified.

The Leiter-R scale, developed as a nonverbal intelligence measurement tool, could be used to assess children, adolescents, and young adults aged from two years, 0 months to 20 years, 11 months, who could not be reliably and validly assessed with traditional intelligence tests. In practice, the test is manageable, and does not require proficiency in perceiving, manipulating, and reasoning with words or numbers, or using any other materials traditionally identified as "verbal". All administration instructions are adapted to a nonverbal format. Because of these features, this scale is widely utilized to assess the intellectual function of children with PDD, especially those who cannot be tested with standard intelligence tests.

The Leiter-R scale potentially allows the obstacle of the impaired communication skills, attention, and behavior observed in these children[24] to be overcome, albeit not completely.

To analyze for any correlation between Leiter-R IQ scores in our sample of 44 children (13 AD, 31 the PDDNOS) and PEP-R overall and domain DQ scores, simple linear regression models were performed considering PEP-R overall and domain DQ scores as dependent variables and Leiter-R IQ as the independent variable; $R^2$ and r (Pearson correlation coefficient) were also calculated. Data were tabulated and analyzed using STATA 10 MP for Mac OS X.

# Results

## Leiter-R IQ

Scores for the Leiter-R are presented in Table 2. The mean nonverbal Leiter-R IQ score for the sample (n = 44) was

**Table 2** Mean Leiter-R IQ scores

| | Mean ± SD | Median | Range |
|---|---|---|---|
| IQ sample (n = 44) | 75.8 ± 15.8 | 76 | 34–112 |
| IQ AD (n = 13) | 70.1 ± 18.4 | 76 | 34–94 |
| IQ PDDNOS (n = 31) | 78.2 ± 14.3 | 79 | 53–112 |

**Abbreviations:** AD, autism disorder; IQ, intelligence quotient; PDDNOS, pervasive developmental disorder not otherwise specified; SD, standard deviation.

75.8 ± 15.8 (range 34–112). The mean nonverbal IQ for the AD group was 70.1 ± 18.14 (range 34–94); this group consisted of eight children with high and five children with low functioning. The mean nonverbal IQ for the PDDNOS group was 78.2 ± 14.3 (range 53–112). This group consisted of 19 children with high functioning and 22 with low functioning.

## PEP-R DQ

Table 3 shows the PEP-R DQ scores for the sample. The mean overall DQ score for the sample (n = 44) was 51.7 ± 145 (range 26–103). The mean overall DQ score for the AD group was 49.8 ± 15.6 (range 26–71); the mean overall score for the PDD-NOS group was 52.6 ± 14.2 (range 32–103).

Mean quotient scores in each of the PEP-R domains tested with the Leiter-R were: imitation 42 ± 20.4; perception 63.39 ± 26.52; fine motor 66.25 ± 18.3; gross motor 56.93 ± 13.4; eye-hand coordination 67.54 ± 18.69; cognitive performance 39.5 ± 14.79; and cognitive verbal 39.32 ± 18.69. Comparison of the Leiter IQ score with the overall PEP-R DQ score using a linear regression model revealed a significant correlation between the IQ and the overall DQ, coefficient = 0.56, $R^2 = 0.41$, r = 0.64, $P \leq 0.05$.

Additionally, all domain DQ scores of the PEP-R revealed significant correlations with the Leiter-R IQ. Using a linear regression model we found a significant correlation between the IQ and DQ for imitation (DQ coefficient = 0.63, $R^2 = 0.21$, r = 0.46, $P < 0.05$), perception (DQ coefficient = 1.03, $R^2 = 0.36$, r = 0.60, $P < 0.05$), fine motor (DQ coefficient = 0.5, $R^2 = 0,16$, r = 0.41, $P < 0.05$), gross motor (DQ coefficient = 0.44, $R^2 = 0.27$, r = 0.52, $P < 0.05$), eye-hand coordination (DQ coefficient = 0.62, $R^2 = 0.32$, r = 0.56, $P < 0.05$), cognitive performance (DQ coefficient = 0.56, $R^2 = 0.39$, r = 0.63, $P < 0.05$), cognitive verbal DQ coefficient = 0.54, $R^2 = 0,22$, r = 0.47, $P < 0.05$). Table 4 shows the correlation analyses comparing the Leiter-R IQ with the PEP-R DQ scores.

**Table 3** Mean PEP-R DQ scores

| | | Mean ± SD | Median | Range |
|---|---|---|---|---|
| Overall DQ sample | | 51.7 ± 14.5 | 52 | 26–103 |
| | Overall DQ AD | 49.8 ± 15.6 | 54 | 26–71 |
| | Overall DQ PDDNOS | 52.6 ± 14.2 | 52 | 32–103 |
| Imitation DQ sample | | 42 ± 20.4 | 42 | 5–91 |
| | Imitation DQ AD | 37.6 ± 25 | 34 | 5–91 |
| | Imitation DQ- PDDNOS | 43.9 ± 18.3 | 43 | 8–82 |
| Perception DQ sample | | 63.39 ± 26.52 | 62.5 | 19–114 |
| | Perception DQ AD | 56.85 ± 28.03 | 54 | 19–98 |
| | Perception DQ PDDNOS | 66.13 ± 25.83 | 66 | 22–114 |
| Fine motor DQ sample | | 66.25 ± 18.03 | 66 | 38–101 |
| | Fine motor DQ AD | 59.77 ± 17.71 | 60 | 39–98 |
| | Fine motor DQ PDDNOS | 68.97 ± 17.74 | 70 | 38–101 |
| Gross motor DQ sample | | 56.93 ± 13.40 | 59.5 | 24–87 |
| | Gross motor DQ AD | 53.54 ± 17.15 | 56 | 24–82 |
| | Gross motor DQ PDDNOS | 58.35 ± 11.52 | 60 | 38–87 |
| Eye-hand coordination DQ sample | | 67.54 ± 18.69 | 68 | 33–103 |
| | Eye-hand coordination DQ AD | 61 ± 15.81 | 65 | 34–89 |
| | Eye-hand coordination DQ PDDNOS | 70.29 ± 19.35 | 74 | 33–103 |
| Cognitive performance DQ sample | | 39.5 ± 14.79 | 38 | 7–85 |
| | Cognitive performance DQ AD | 34.08 ± 13.85 | 32 | 18–60 |
| | Cognitive performance DQ PDDNOS | 41.77 ± 14.8 | 39 | 7–85 |
| Cognitive verbal DQ sample | | 39.32 ± 18.69 | 41 | 10–78 |
| | Cognitive verbal DQ AD | 34.54 ± 20.24 | 29 | 10–70 |
| | Cognitive verbal DQ PDDNOS | 41.32 ± 17.97 | 42 | 14–78 |

**Abbreviations:** AD, autism disorder; DQ, developmental quotient; PDDNOS, pervasive developmental disorder not otherwise specified; SD, standard deviation; PEP-R, Psychoeducational Profile Revised.

**Table 4** Correlation analyses between Leiter-R IQ scores and PEP-R DQ scores

| PEP-R DQ scores | $R^2$ | *P* |
|---|---|---|
| Overall | 0.41 | <0.05 |
| Imitation | 0.21 | <0.05 |
| Perception | 0.36 | <0.05 |
| Fine motor | 0.16 | <0.05 |
| Gross motor | 0.27 | <0.05 |
| Eye-hand coordination | 0.32 | <0.05 |
| Cognitive performance | 0.39 | <0.05 |
| Cognitive verbal | 0.22 | <0.05 |

**Abbreviations:** IQ, intelligence quotient; PEP-R, Psychoeducational Profile Revised; DQ, developmental quotient; Leiter-R, Leiter International Performance Scale Revised-Visualization and Reasoning Battery

## Discussion

The validity of the original PEP-R has been amply confirmed in the literature. As reported by Steerneman et al,[25] Schopler and Reichler[26] referred a study in which the developmental scores of children with autism, children with intellectual impairment, and typically developing children were compared. The results showed a strong similarity between the developmental scores of children with intellectual impairment and those of typical children. For example, the PEP-R score obtained by a child with an intellectual impairment and a developmental age of three years was the same as that of a typical child with a chronological age of three years. Moreover, children with autism varied in their developmental profile, whereas children with intellectual impairment exhibited equal retardation of all developmental functions.

The behavioral scale of the PEP-R is derived from the Childhood Autism Rating Scale,[20] a diagnostic instrument commonly used for the assessment of children with PDD, which draws on the DSM-IV-TR.[19]

Validation studies of the original PEP also included comparisons with a number of other standardized assessment instruments and reported that total PEP scores were significantly correlated with scores from the Merrill-Palmer Scale,[27] Vineland Social Maturity Scale,[28] Bayley Scales of Infant Development,[29] and the Peabody Picture Vocabulary Test.[30] However, the manual for the PEP-R highlights that the original PEP was found not to correlate with scores obtained using the Wechsler Intelligence Scales or the Leiter International Performance Scale.[26]

Since that time, little published research has compared the revised version of the PEP with standardized intelligence tests with the aim of surmounting the difficulty of assessing the mental abilities of children with PDD. Steerneman et al[25] reported a strong correlation between the PEP-R total developmental score and the total mental age score for the Snijders-Oomen Nonverbal intelligence test (SON 2 ½-7),[31] a nonverbal measure of intelligence.

In two recent studies, DQ scores from PEP-R were compared with scores from the Stanford-Binet Intelligence Scales and with scores from the Merrill-Palmer Scale of mental tests. The results revealed a significant correlation between the DQ of the PEP-R and the IQ scores from the Stanford-Binet and IQ scores from the Merril-Palmer Scale of mental tests in a Chinese sample.[13,32] In our study, a significant correlation was found between the overall PEP-R DQ and the Leiter-R nonverbal IQ. All items of the PEP-R DQ scores were significantly related to the total Leiter-R IQ scores. Consequently, all items significantly contribute to determining the correlation between IQ on Leiter and overall DQ. To our knowledge, no published research has compared PEP-R DQ and Leiter-R IQ scores.

Our findings suggest that the DQ from the PEP-R can foster a reasonable estimate of the intellectual capacity of children with PDD. The tool covers a wide developmental range, offers structured and attractive material, and separates language items from general assessment items. Therefore, the PEP-R is also partially able to assess low-functioning children with significant language and social deficits and with behavioral disturbances, obtaining data on the cognitive abilities of otherwise untestable children.

Moreover, the correlation found between the Leiter-R IQ and the domain DQs of the PEP-R offers further advantages in delineating abilities in each area, and obtaining data which would be lost when using aggregate scores such as the IQ. This information acts as the basis for designing subsequent intervention, which must start from the developmental level of the child in each domain. These findings suggest that administration of the PEP-R to children of most ages, to assess their cognitive ability and the severity of behavioral disturbances, can be a useful tool for estimating the cognitive functioning of children with PDD.

For future research, it could be useful to increase the number of cases and see if the correlation between the Leiter-R IQ and the domain DQs of the PEP-R is maintained over time in the development of the individual child. The contribution of this work is that it aids both the diagnosis and early intervention, although DQs of the PEP-R can overestimate or underestimate the cognitive abilities of the child, so the results should be interpreted with caution and verified over time. However, this information allows families to create different expectations also, depending on the ratio of DQs in

the PEP-R. It is possible that introduction of the PEP-3 has caused a certain loss of useful information, since there is no DQ in this version.

## Disclosure

The authors report no conflicts of interest in this work.

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