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RESEARCH REPORT

Development and norming of the Hungarian CDI-III: A screening tool for language delay

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Abstract

Background: Difficulties in language development are related to social and emotional problems, lower academic outcomes, and lower quality of life from childhood to adolescence. These grave consequences might be significantly reduced by timely identification and professional support. The introduction of systematic screening for language delay (LD) in 3-year-old children in Hungary was based on the recent adaptation of the MacArthur–Bates CDI-III (HCDI-III).

Aims: To explore the relevant psychometric properties of the HCDI-III; to identify factors characteristic of the families and children influencing language development at the age group under investigation; and to evaluate the adequacy of the tool for the purpose of screening LD in kindergarten at the age of 3 years.

Methods & Procedures: The norming study of the HCDI-III was conducted in a collaborative research project with the Metropolitan Pedagogical Services in Budapest. HCDI-III parent report forms along with a demographic survey form were distributed to parents of all Hungarian-speaking children between the ages of 2;0 and 4;2 without special education needs. The normative sample comprised data from 1424 children aged 2;0–4;2 with 51.1% boys and 48.9% girls. The data set contained information including language skills, basic demographics, birth conditions, health issues and socio-economic status (SES).

Outcomes & Results: In the HCDI-III form, six outcome variables were created to cover the domains of expressive vocabulary, morphosyntax and language use. Statistical analyses revealed appropriate psychometric properties of five outcome variables that showed a normal distribution and were strongly correlated to age. Outcomes of girls were slightly (but significantly) higher on scales corresponding to vocabulary, syntax, language use and productivity. Most variables were highly correlated with one another even with age partialled out. Multiple regression analyses revealed significant effect of age, gender and parental education on all main outcome variables. Neither one of the other eight predictors, including familial and birth-related factors, affected linguistic outcomes in our sample.

Conclusions & Implications: The results are consistent with the majority of Communicative Development Inventory (CDI) studies, and support the psychometric eligibility of the instrument for screening purposes between 30 and 50 months. As certain regions of Hungary are characterised by a high prevalence of low-SES families, more research is needed to adapt the screening procedure and subsequent measures to their needs.

What this paper adds: What is already known on the subject:

- Difficulties in language development are related to lower social and academic outcomes and lower quality of life from childhood to adolescence. These grave consequences might be significantly reduced by timely identification and professional support. Structured parent report forms such as the MacArthur–Bates CDI are widely accepted methods for screening children with LD.

What this paper adds to existing knowledge:

- This study reports the Hungarian adaptation and norming of the CDI-III form. Statistical analyses revealed appropriate psychometric properties of most of its sections. Language outcomes were affected by age, gender and parental education on all main outcome variables in children between 2 and 4 years of age.

What are the potential or actual clinical implications of this work?:

- The results support the psychometric eligibility of the HCDI-III instrument for screening purposes. The introduction of the screening procedure in clinical practice is expected to improve early support of children with language difficulties and reduce risks of developmental problems related to language disorders.

KEYWORDS

Hungarian, language delay, MacArthur–Bates CDI, parent report, screening

INTRODUCTION

Difficulties in language development are related to social and emotional problems, lower academic outcomes, and lower quality of life from childhood to adolescence (Durkin & Conti-Ramsden, 2007, Eadie et al., 2018). These grave consequences are significantly reduced in children whose language disorder has been resolved by entry to primary school (Bishop & Adams, 1990; Stothard et al., 1998; Simkin & Conti-Ramsden, 2006; Conti-Ramsden et al., 2009). Timely detection and professional support of children with language difficulties is therefore key to reducing their developmental lag and mitigating further risks. However, early screening of language delay (LD) is a challenging task due to the considerable variability and unstable nature of early language development under 3–4 years (Dale et al., 2003; Henrichs et al., 2011). Since the late 1980s, effective assessment instruments measuring children's early vocabulary, initial sentence formation and non-verbal communication through structured parent report have been constructed, validated and become widely accepted (Rescorla, 1989; Fenson et al., 1993, 2007). The most popular parent report tool, the MacArthur–Bates Communicative Development Inventory (CDI) consists of two instruments, the CDI Words and Gestures (W&G) and the CDI Words and Sentences (W&S) forms to be used with children between 8–18 and 16–30 months of age, respectively, and also later with children showing delayed development (Fenson et al., 2007). Based on the principles of these instruments, an additional short-form called CDI-III has been constructed for evaluating language in 3-year-old children (Dale et al., 2001; Fenson et al., 2007). The aim of the present study is to report the adaptation and norming process of the Hungarian version of the CDI-III (called

HCDI-III) in order to create a screening tool for LD in the country.

Early variability in language development and screening accuracy

The pace of early language development is highly variable up to 3–4 years. Evidence of word comprehension first appears between 8 and 10 months, but the size of receptive vocabulary shows great variability right from the beginning. According to the US norming study of the CDI, some children's receptive vocabulary exceeds 200 words, while others' word comprehension is limited to fewer than 25 words at 12 months (see Fenson et al., 1993, for English; Caselli et al., 2012, for Italian; and Bleses et al., 2008, for Danish). The same holds for expressive vocabulary. Although many children start producing words at 12 months and reach a considerable vocabulary size of 100–200 words at 16 months, median expressive vocabulary is around 50 words at 16 months. However, starting word production only at 18 months or even later is also quite common (Fenson et al., 1993; Caselli et al., 2012; Bleses et al., 2008). This great variance in word production is still present at 24 months but decreases significantly as children approach the end of their third year. As for grammar, the expansion of syntactic development parallels that of vocabulary in showing both steady growth with age and wide variation from 18 to 30 months. The use of grammatical suffixes in English emerges from 16 months and children use two different suffixes on average at 2 years. Overregularization errors that mark the beginning of extracting grammatical regularities are prominently present from 24 months, but there are many children who produce only a few of them at 30 months. First word combinations emerge between 16 and 24 months, but maximum sentence length varies between one and nine morphemes at 24 months and between four and 14 morphemes at 30 months (Fenson et al., 1993).

This wide variance makes establishing reliable and valid criteria for distinguishing between typical versus delayed language development a challenge. Following the internationally accepted criteria, language development is considered delayed if a child's expressive vocabulary does not reach 50 words or she has not started producing word combinations, that is, developing grammar (Rescorla, 1989). A slightly different, statistically based approach is adopted by others (Thal & Bates, 1988; Fenson et al., 1993) who consider children with expressive vocabulary below the 10th or 15th percentile and producing no word combinations as late talkers. Based on large sample studies (e.g., Hamilton et al., 2000) the 50-word-criterion at 2 years is by and large equal to the 10th percentile criterion. Rescorla's (1989) criteria selects 18% of 2-year-olds in her sample of more than 500 children.

Looking at later time points, 10.7% of 3-year-old and 11.5% of 4-year-old children have been identified as showing LD based on parent report (CDI) using the 15th centile criterion in at least two out of three subparts (Dale et al., 2003). However, developmental trajectories in children with LD are still highly variable and there is a significant inconsistency between measurements at different time points. Dale et al. (2003) compared measurements taken at 24, 36 and 48 months and reported that fewer than half of the children with early LD at 2 years show persistent language difficulties 1 or 2 years later (44.1% at 3 years and 40.2% at 4 years) with most of these children catching up to the normal range spontaneously in 1 or 2 years. This corresponds to the clinical intuition shared by many professionals that recognizes LD as a significant risk factor for language disorders. However, Dale et al. (2003) also found that most of the children showing low language capabilities at 3 or 4 years have not been classified as LDed at 2 years, referring to the low predictability of language outcomes based on early assessments. This pattern of findings is supported by other studies as well (Feldman et al., 2005; Westerlund et al., 2006, in Swedish; Lyytinen et al., 2001, in Finnish).

Henrichs et al. (2011) distinguishes between three different subtypes/trajectories of persistent, transient and late-onset LDs in their large-sample longitudinal study with measurements taken at 18 and 30 months in Dutch language. The corresponding proportions of children falling into these three categories are 6.2% with transient LD (low expressive vocabulary at 18, but normal scores at 30 months), 6.0% with late onset expressive vocabulary delay (normal expressive vocabulary at 18 but below cut-off scores at 30 months), and 2.6% with persistent expressive vocabulary delay (at both time points) in the whole sample. A prediction model including demographic and familial factors along with early receptive and expressive vocabulary scores could only explain 17.7% of the variance in 30-month expressive vocabulary with sensitivity and positive predictive values for the CDI-N being very low. Reflecting on this result, Henrichs et al. (2011) argue that there is little public health benefit in screening for LD at 18 months and suggest that screening should be conducted at later points in development. Zambrana et al. (2014) conducted a longitudinal study including children at later ages from 3 to 5 years in Norway and found similar proportions of children falling to the classes of persistent (3%), transient (5%) and late-onset (6.5%) LD. Their prediction model included several familial and contextual factors and was able to predict the three LD trajectories differently. The most distinguishing characteristics of children with persistent LD are late-talking family members, poor early receptive language and male gender. Family history of reading and writing difficulties was related to persistent and late-onset LD, whereas transient LD was related to family history of unintelligible speech. Zambrana et al. (2014) argue that the risk factors identified in the background of the different LD trajectories could assist in screening for different LD trajectories at different time points.

Ebbels et al. (2019) discuss existing evidence for intervention in children with language disorders. They argue that screening should be able to differentiate between children at risk of a persisting disorder who need individualized intervention and those likely to resolve their language difficulties either spontaneously or with non-specialized educational support. This would allow for targeting the former group with timely and specialized treatment in order to improve efficacy and for the economical use of professional resources. To this end, all possible factors related to later difficulties should be considered differently by splitting them into 'red flags' and 'risk factors'. 'Red flags' are considered individual behavioural markers indicating the need for assessment by an SLT without delay, including lack of communicative intention or no words at 2–3 years or severe comprehension difficulties or lack of multiword utterances at 3–4 years. In contrast, 'risk factors' are associated with language difficulties at a group level but by themselves do not raise the need for immediate SLT assessment. These factors might improve the predictive accuracy of early behavioural indicators, as Rudolph (2017) points out in her systematic review which identified low maternal education, male gender, later birth order and low 5-min Apgar score as clinically relevant predictors of language impairment.

In a systematic review aiming to gather accessible evidence for early language screening and intervention, Wallace et al. (2015) conclude that although some screening instruments are capable of accurately selecting children with LD or disorder, there is a great variability in sensitivity and specificity. Studies using the CDI toddler form generally produced consistent and acceptable levels of sensitivity and specificity (70%) at each age group, but accuracy drops when 3-year-olds' language is predicted based on data from 2 years. Law and Roy (2008) cite Westerlund et al. (2006) who argue that in case of a severe disorder with low prevalence priority should be given to the high sensitivity of a measure even at the cost of low specificity in order to find as many cases as possible. Law and Roy (2008) conclude that although CDIs are versatile, efficient and valid measures of language development in young children, reliable predictions about individual language outcomes based on early measures is still a challenging task. The problems of sensitivity are apparently shared by most types of early measures due to the variability of developmental trajectories in both typical and delayed development. Highest sensitivity might be achieved by taking into account all accessible factors known to be related to LD.

The ultimate goal of early screening of children with LD is to detect children whose development can subsequently be significantly facilitated by some form of early intervention. However, the effectiveness of early screening and intervention is questioned by Wallace et al. (2015) whose systematic review could not identify any well-designed, well-conducted studies directly proving that screening for speech and LD or disorders improve language outcomes. They argue that although most of the trials conclude with positive results in terms of language outcomes, confident interpretation is limited by the small size of trials, the lack of replicated positive findings, the great variability in the age of children treated, intervention agents, intensity, manualized content and strategies and so forth. Therefore, clear recommendations for early intervention strategies cannot be made at present. In recent years, however, large-sample randomized controlled trial studies investigating effectiveness of early intervention delivered by parents (Suskind et al., 2016; Burgoyne et al., 2018) and trained teaching assistants (Fricke et al., 2017) have been put forward providing evidence that early language intervention can be delivered successfully to children with oral language difficulties. Further studies following this path should be able to establish the required evidence base for effective early language intervention.

In sum, variability in early pathways of language development makes accurate language screening a challenge. Screening should be performed adopting an optimal combination of strategies in terms of method, age of screening, risk factors and other information resources considered. The evidence discussed above suggests that screening results at later ages of 3–4 years (compared with 18–24 months) might better reflect children's long-term language outcomes avoiding most of the false positive results of late bloomers but grasping children with persistent language difficulties along with those with late-onset LDs. In terms of method, there is considerable evidence that parent report instruments such as the CDI can serve as a valid screening tool with extensions collecting data on risk factors related to poor language outcomes. In the following, we present studies on the development, adaptation and diagnostic applications of the CDI-III.

CDI-III

The original CDI-III was aimed to serve as an effective outcome measure in language development research as well as an evaluation tool for clinical services supporting children with LD from 3 years of age. The instrument consists of a 100-item vocabulary checklist, a 12-item syntax scale similar to the sentence pairs section measuring syntactic complexity in CDI-II Words & Sentences, and a third section with 12 items focusing on common situations of language use. Parents are also requested to provide three examples of the longest sentences from the child's recent expressive repertoire. All items fit in two pages of a single sheet, thus forming a very economical instrument. The CDI-III has been normed with children between 30 and 37 months of age. Although initially children from a wider age range had been involved in the norming sample, ceiling effects appeared in children over 37 months (Fenson et al., 2007). This, however, does not interfere with the applicability of the test for the purpose of screening language difficulties.

Studies of psychometric properties

There is a growing body of evidence on the validity and classification accuracy of the instrument. Validity studies have been carried out using standard tests of language skills administered directly with the child in order to compare the results of different data sources. In a sample of 113 apparently healthy children at 3 years of age, the three main sections (Vocabulary, Sentences, Using language) of the CDI-III showed low to moderate significant correlations with standardized measures of receptive vocabulary (Peabody Picture Vocabulary Test-Revised (PPVT-R), r = 0.41 with the Vocabulary, r = 0.49 with Sentences and r = 0.49 with the Using language sections), the number of different words (r = 0.35 with the Vocabulary, r = 0.41 with Sentences and r = 0.26 with the Using language sections) and mean length of utterance (MLU) (r = 0.33 with Vocabulary, r = 0.42 with Sentences and r = 0.31 with the Using language sections) from conversational samples, and the Verbal scale of the McCarthy Scales of Children's Abilities (r = 0.49 with Vocabulary, r = 0.48 with Sentences and r = 0.47 with the Using language sections) (Feldman et al., 2005).

Perra et al. (2015) examined the convergent validity of combining parent-based reports of non-verbal cognitive abilities (PARCA3) and verbal abilities (CDI-III) in relation to the Bayley-III Scales of Infant and Toddler Development in a sample of 3-year-old children born late pre-term (N = 185). There was a significant positive correlation between the CDI-III and the Bayley-III Expressive Communication scale (partial r = 0.43) and between the CDI-III and the Cognitive and Receptive Communication scales (partial r = 0.35 and partial r = 0.32, respectively). The combination of the CDI-III and the PARCA3 provided a significant contribution to prediction of the Bayley-III scores explaining 15% of variation in the Bayley-III cognitive scores (added to 18% of variance explained by age, gender, parity, birth weight and an index of social risk). These studies revealed low to moderate significant correlations between the CDI-III and measures of expressive and receptive communication administered by an expert examiner.

In addition to validity, classification accuracy is also key in the clinical implementation of the instrument as decisions on individual children's further treatment need to be supported by strong evidence. In a sample comprising children with and without language impairment (nine and 49 children in each group, respectively) between 30 and 45 months, the CDI-III could discriminate language impaired children from those with typically developing language with high classification accuracy (Skarakis-Doyle et al., 2009). In this study, participants were assigned to the LI group based on their status in treatment receiving services for both expressive and receptive LI. Only one participant from each group was misidentified, so classification accuracy was overall 96.6% with stronger specificity (98.0%) than sensitivity (88.9%). The authors acknowledge that their participants with LI predominantly had both expressive and receptive LI thus forming a group with more severe language disabilities. Screening accuracy should be interpreted in this context considering that although children with severe LI can be accurately discriminated using the CDI-III further studies are needed to investigate screening accuracy in children with milder or expressive-only language impairments.

As part of a set of different language measures, the CDI-III has also been used in the Early Language in Victoria Study aiming to distinguish longitudinally different language profiles in pre-school children (Ukoumunne et al., 2012). The sample included 1113 children assessed at 8, 12, 24, 36 and 48 months with CDIs administered at 24 (CDI-WS) and 36 (CDI-III) months. Participants were classified into five classes (Typical, Precocious (early), Precocious (late), Impaired (early) and Impaired (late)) based on their longitudinal pattern of language profiles using latent class analysis. Children in the Impaired (late) class were classified as impaired with 73.4% and as typical with 26.6% probability at 36 months using the CDI-III at 36 months, while children in the Typical class was classified as impaired with only 2.9% and typical with 97.1% probability. Assessing the same population data, Skeat et al. (2010) analysed the predictors of parents seeking help or advice about their children's communication development. The three main subparts of the CDI-III administered at 36 months proved to be a significant predictor of parental help-seeking due to communication problems at 4 years. Children's performance at or below 10th percentile in the Vocabulary section positively predicted parents seeking help at 40% (sensitivity = 25.0%, specificity = 92.7%) with similar predicting values for the Grammar section (positive predictive value = 35.4%, sensitivity = 31.9%, specificity = 88.7%) and the Language use section (positive predictive value = 36.0%, sensitivity = 29.0%, specificity = 90.0%) (Skeat et. al 2010).

The results of the latter study might not be directly comparable to the previous ones as predicting parents seeking help is possibly influenced by factors other than the impaired language skills of the child including parental awareness and regional accessibility of services. However, the studies of Skarakis-Doyle et al. (2009) and Ukoumunne et al. (2012) were able to reveal fair sensitivity and high specificity in classification accuracy using the CDI-III with very different sample sizes and research designs. These results support the eligibility of the parent report form in the clinical evaluation of language development in children over 3 years of age. Nevertheless, more research is needed to explore classification accuracy in a wider range of settings including children with milder or expressive-only language impairments and those with low-socio-economic status (SES) family backgrounds. Moreover, clinical decisions can be further supported by the integration of different data sources such as teacher's reports and data on risk factors related to language difficulties.

Adaptations

Just like the first two CDI forms, the CDI-III has been adapted to different languages, gaining more international popularity in recent years. The Spanish, Basque and Norwegian forms were adapted directly from the original CDI-III keeping its structure and main sections (see Guiberson, 2008, for Spanish; Garcia et al., 2014, for Basque; and Garmann et al., 2019, for Norwegian). However, the Swedish form SCDI-III deviated from the original instrument to some extent in order to extend the upper age limit to 4 years (Eriksson, 2017). Items in the vocabulary section have been revised and sections for measuring metalinguistic awareness and pronunciation accuracy have been added (Eriksson, 2017). The Swedish form served as the basis of the recent Estonian adaptation put forward by Tulviste and Schults (2020) and the structure of the Swedish CDI-III vocabulary section were also used in the recent development of the CDI-III for European Portuguese along with carefully adapted sections for syntax for each language based on earlier CDI-WS forms and spontaneous language samples (Cadime et al., 2021). Studies of validity and classification accuracy have also been conducted and published for some of the adaptations with largely successful results.

Evidence for validity is available for the Spanish INV-III (Guiberson & Rodríguez, 2010), the Swedish SCDI-III (Odeskog & Stenberg, 2015), the Estonian form ECDI-III (Tulviste and Schults (2020) and the European Portuguese CDI-III (Cadime et al., 2021). The validity of the Swedish and Portuguese CDI-III instruments has been studied in typically developing children while the studies on the Spanish and Estonian forms also included groups of children with language difficulties. Odeskog and Stenberg (2015) tested the validity of the Swedish form in a sample of 41 typically developing children aged 3;0–3;11 and found low correlations of the Vocabulary section with the Peabody Picture Vocabulary Test ($r = 0.324$) and the Boston Naming Test ($r = 0.368$). Cadime et al. (2021) reported that the Vocabulary total score and the Syntax score of the European Portuguese CDI-III showed moderate correlations with the language score of the Griffiths Mental Development Scales ($r = 0.486$* and $r = 0.445$*, respectively) in a small sample of 23 typically developing children aged 30–48 months.

The validity of the Spanish form INV-III was assessed by Guiberson and Rodríguez (2010) in 48 children between 36 and 62 months of whom 22 children were assigned to the expressive LD group based on scores below 85 in the Preschool Language Scale—4 (PLS-4) Spanish version. The INV-III moderately correlated with the PLS–4 Spanish ($r = 0.62$), establishing concurrent validity. In the study introducing the Estonian form ECDI-III, Tulviste and Schults (2020) also investigated the validity of the instrument through correlations with the Estonian CDI-WS form (ECDI-II) and a standardized examiner-administered language assessment (New Reynell Developmental Language Scales—NRDLS) in a sample of 100 children aged 34–39 months with 20 of them showing language difficulties as reported by their parents. Scores of the ECDI-III Vocabulary section and the ECDI-II Vocabulary total score correlated significantly and strongly ($r = 0.87$) while correlation between the scores of grammar parts of the two inventories was also strong ($r = 0.81$), and the correlation between the scores of sentence complexity parts was moderate ($r = 0.52$). All sections of the ECDI-III correlated significantly with the Reynell DLS production score and comprehension score: ECDI-III Vocabulary section, $r = 0.58$ and 0.65, ECDI-III grammar section, $r = 0.58$ and 0.55, ECDI-III sentence complexity section, $r = 0.47$ and 0.43, respectively.

In general, validity of the adapted CDI-III forms has been largely supported by the studies discussed above. Low to moderate correlations has been found between the Swedish and Portuguese CDI-III forms and the corresponding standard measures of language skills in samples of typically developing children. These studies detected similar levels of concurrence between parent report data and standardized tests as with the original CDI-III (Feldman et al., 2005; Perra et al. 2015). Higher correlations could be achieved in case of the Spanish INV-III and the Estonian CDI-III where the samples included children with language difficulties. This difference may be due to the fact that correlation coefficients are generally lower if there's a low variance in the characteristic of the sample. The inclusion of data from children with language difficulties results in higher variance and might contribute to the higher correlations. However, it might also suggest that parent report forms are less sensitive to milder differences within normal variation than more significant differences observed in children with language problems.

To date, only a few studies of classification accuracy of the adapted CDI-III forms have been conducted including those of the Spanish INV-III (Guiberson & Rodríguez, 2010) and the Estonian form ECDI-III (Tulviste & Schults (2020). The classification accuracy of the Spanish form INV-III was assessed in the above-mentioned study by Guiberson and Rodríguez (2010). The INV-III displayed fair sensitivity (82%) and specificity (81%) in distinguishing between children previously assigned either to the typically developing group or the expressive LD group based on scores in the Preschool Language Scale—4 (PLS-4) Spanish version. Tulviste and Schults (2020) also investigated classification accuracy in their validity study discussed above. The children with reported language difficulties gained lower scores in all sections as a group, however, sensitivity scores were unacceptably low (50–61–56% for the Vocabulary, Grammar and Sentence Complexity scores) while specificity scores were fair (86–88–83%, respectively). These latter results on predictive values might have been influenced by the fact that identification of children with language difficulties was largely based on parental judgment. Parental decisions in this regard perhaps reflected their concern more than exact measures and could have been guided by levels of articulatory accuracy rather than language abilities which is measured by the CDI. In sum, evidence for classification accuracy of the adapted CDI-III forms is scarce with the existing studies showing promising results in specificity and mixed results in sensitivity. Developments in the latter respect is essential for the clinical application of the forms in order to minimize the number of false-negative screening results as suggested by Law and Roy (2008) and Westerlund et al. (2006).

Clinical and research applications

In accordance with the original aims of its creation the CDI-III is widely applied in clinical settings as well as in research studies with typically developing children and with clinical populations. Two characteristic groups of children typically studied using the CDI-III are children with autism spectrum disorder (ASD) and those with hearing impairments. The CDI-III has been administered to monitor language outcomes in studies investigating the effects of otitis media on language skills during the first 3 years of life (Feldman et al., 2003), language skills and social functioning in deaf and hard of hearing preschool children (Netten et al., 2015) and the influence of word characteristics on the lexical development of children with cochlear implants (Han et al., 2015). The characteristic social communication difficulties of children with ASD makes it difficult for them to be engaged in formal situations such as a language assessment especially at early ages. Parent report methods, however, allow the researcher and the clinician to access parents' judgments as a valid data source to evaluate the levels of language in children with ASD. In the last decade, a number of ASD-related research studies relied on the CDI-III including those focusing on the development of coordinated communication in infants at risk for ASD (Parladé & Iverson, 2015), the perceptual influences in word learning (Tek et al., 2008; Potrzeba et al., 2015), the correspondences between early parent–infant interactions and language outcome (Northrup & Iverson, 2015), gesture development (LeBarton & Iverson, 2016), functional actions with tools (Sparaci et al., 2018) and joint attention and vocalisation (Heymann et al., 2018).

The CDI-III has also been administered in research studies where a fast and effective method is required to control for verbal abilities as a background variable or to have a broad outcome measure of language skills. Such studies include twin studies aiming to evaluate genetic evidence related to early lexical and grammatical development (Dionne et al., 2003), or the etiology of variation in language skills changes with development (Hayiou-Thomas et al., 2012) and also those focusing on complex relations between processing load and theory of mind (Scott & Roby, 2015) or parenting and other environmental factors and children's executive functions (Linebarger et al., 2014).

Background of the present study

There are many examples of how forward-looking change in the legal regulation of public education creates a need for methodological development in the field of speech and language therapy and childhood education. Fenson et al. (2007) reported that the Individuals with Disabilities Education Improvement Act of 2004 (or IDEA 2004) in the United States mandates that schools provide appropriate services for children between 3 and 5 years of age with developmental delays. As the need for effective tools for screening language abilities at age 3 has increased, the CDI-III has been developed to fill this gap. Likewise, the Norwegian Framework Plan for Kindergartens (cited by Garmann et al., 2019) provides monitoring children's communication and language in order to identify and support children who demonstrate various types of communication problems. Thus, the legal environment required professional efforts to enable the staff to detect children in need of support that in turn justified the development of the Norwegian adaptation of the CDI-III.

The motivation of the present study is rooted in a similar situation in Hungary. Early support for children with LD has recently received legislative support by subsequent changes in law. First, from 2015, pursuant to the National Public Education Act children are mandated to attend kindergarten at least four hours a day from the beginning of the school year in which they reach the age of three by 31 August. Subsequently, in 2016, a ministerial decree on the operation of pedagogical professional institutions made the screening of language development in 3-year-old children mandatory for speech and language therapists. This legal step has been the first official measure in Hungary to create a system of comprehensive early childhood language screening. It was clear upon the introduction of the new legal rules that an effective tool is needed to make early screening viable across the country.

Previous CDI adaptations in Hungarian

Earlier, the original CDI W&G and W&S forms has been adapted to Hungarian resulting in the HCDI forms nicknamed KOFA (which is an acronym of the Hungarian phrase for CDI but also an existing word meaning 'costermonger') (Kas et al., 2010). The adaptation process took into consideration both cultural and linguistic differences between the original English and the targeted Hungarian version. Adequacy of each item in the vocabulary checklists and the gestures, games and routines sections has been investigated. Items in the HCDI Words & Gestures form are by and large the same as in the original. There are only a few gestures, social games and activities that have been replaced due to cultural differences. In the vocabulary list, a few items have been omitted, for example, there is no monomorphemic word for 'watch' in Hungarian, just a compound like 'arm-clock' which is not typically used by infants, so this item has been omitted along with a few others due to similar reasons. The vocabulary checklist of the HCDI Words & Sentences form has been treated similarly.

Contrary to the vocabulary section, we had to change the Grammar sections in the W&S form more drastically due to structural differences between the source and the target language. Hungarian language differs considerably from English being a non-configurational language where word order is relatively flexible and morphology is the core marker of grammatical functions (see Kas & Lukács, 2012; and Lukács et al., 2013, for brief summaries). Hungarian has a very rich system of suffixes both in the verbal and the nominal paradigms. Suffix combinations are possible and frequent; theoretically, there are hundreds of different forms in which a noun can appear, taking all possible suffixes and their well-formed combinations into account. There are 18 different case markers with the nominative assumed to have a zero-case marker, for example, *ház* 'house—nominative', *házat* 'house—accusative', *házban* 'in (the) house', *házból* 'from (the) house', *házhoz* 'to (the) house' *házzal* 'with (the) house' and so on. Case suffixes can combine with the plural and with possessive markers, in a fixed order: the case marker is always word-final, and all nouns have to end in a case marker, for example, *házakat* 'house—plural accusative', *házamban* 'in my house'.

Thus, the relations expressed by English prepositions—for example, 'on', 'in', 'from'—are assigned to inflections in Hungarian with two to three different allomorphs representing each one. Considering that these bound morphemes are not free-standing elements and there are several surface forms of each morpheme, they were assumed to be too abstract for non-expert parents to recognize them in a checklist format and make valid judgments concerning their occurrence in their child's speech. Thus, all case marking morphemes and some characteristic components of the system of verb inflections has been added to the Word endings/Part I section. Following the pattern of items in this section, Hungarian-bound morphemes could be presented more clearly with a brief explanation and examples such as the following:

Spatial relations are expressed by the endings of words. Has your child begun to say words with these **endings**? If yes, please provide examples. Does she produce words with -ba/-be 'into' endings, as in ágy**ba**, víz**be**, bolt**ba** 'into bed/water/shop'? Does she produce words with -ban/-ben 'in' endings, as in doboz**ban**, autó**ban**, bili**ben** 'in box/car/potty' and so on.

As a result, the original Word endings/Part I section has been expanded to contain 18 items compared with four items in the original CDI W&S form.

A considerable proportion of items in the syntactic complexity part (Section E) had to be replaced as some of the typical structural patterns and simplifications English children produce are not observed in Hungarian. A set of typical morphosyntactic phenomena that is characteristic of Hungarian children's early expressive language has been identified based on speech samples from children between 2 and 3 years. The adapted Complexity section comprises 28 sentence pairs following the original CDI concept featuring examples of typical grammatical patterns and structural reductions in Hungarian child language in the first member of sentence pairs with the same sentence meaning in a completed and well-formed structure as the second choice.

According to validity studies conducted with selected subsections of the HCDI W&S form, parents' responses are very much in line with their 2-year-old children's language use (Kas et al., 2010). The validity study of the vocabulary checklist compared parental judgments in the Animals section with the children's performance in a picture naming task. In the picture naming task, each child had to name one by one the same set of animals listed in the checklist. The correlation between the number of animal names produced by the children and those reported by the parents was very high and significant (0.98; $p < 0.001$), just like the correlations between parental judgments and children's naming calculated separately for each item in the section (0.88–1.0).

The validity study of the grammatical morphemes section compared parent report data for 6 case marking morphemes with locative meaning like 'in', 'into', 'out of' and so on. with the children's performance in a novel elicited production task with toy animals. In this task, the experimenter moved a small toy rabbit playing hide-and-seek with her mother. The mother rabbit's eyes were blindfolded. The children's task was to tell the mother rabbit where the small rabbit was/was moving to/was moving away from. Answers were evoked by direct questions, for example, 'Where did the bunny go? Where is she hiding now? Where is she peeking out of?' Parents reported the use of 3.48 morphemes on average (out of 6), while children produced 2.18 morphemes on average in the evoked production task. The correlation between the number of grammatical morphemes used by the children and reported by the parents proved to be very high and significant (0.849; $p < 0.001$) that reveals the broad validity of parental report in this regard. The correlations for each morpheme were also significant but showed a somewhat greater variability between 0.51 (moderate) and 0.86 (very strong). It thus seems that although parents are not as accurate in specifying the grammatical bound morphemes their children use as they were in the animal names section, they are still able to give accurate estimates of the number of morphemes their children use. In sum, these studies proved the validity of subsections in both the vocabulary and the grammar sections the latter of which being specifically developed for the Hungarian CDI (Kas et al., 2010).

Development of the HCDI-III

The adaptation process of the CDI-III followed the procedure applied earlier with the W&G and W&S forms. Translated items in the vocabulary section had been examined one by one and frequency of occurrence of each item has also been considered. Culturally inappropriate or ambiguous items and those with very low frequency were omitted. For example, Hungarian children are not typically familiar with reindeers, so this item had been replaced with 'roe'. The word 'drum' translates to 'dob' in Hungarian but that is homonymous with the verb meaning 'throw' and thus has been replaced with 'guitar' to avoid ambiguity. The word 'leave' is translated as *távozik* in Hungarian but it is a highly formal word virtually non-existing in 3-year-old children's language; it had been replaced with a different verb. The system of personal pronouns is much more complicated in Hungarian as each personal pronoun, for example, 'I' or 'they' has its different form according to each grammatical case. Some examples of the second person singular pronoun are *te* 'you—nominative', *téged* 'you—accusative', *neked* 'you—dative', *veled* 'you—dative', *benned* 'in you', *tőled* 'from you' and so on. Therefore, the set of pronoun items in the HCDI had been expanded compared with the original. Function word items not present in English such as postpositions, verbal modifier adverbials and some question words had also been added to the list in order to represent closed-class vocabulary as well. Overall, the vocabulary list has thus been somewhat expanded yielding a checklist comprising 124 items.

For the Sentences section, 12 items of the sentence pairs that had been adapted for the HCDI W&S form were selected. The Using language section was translated and completed by adding two questions related to children's use of specific morphologically complex forms for asking for permission and for expressing conditional intentions. Parents are also requested to provide 3 examples of the longest sentences from the child's recent expressive repertoire. A short version of the Word endings Part 2 checklist of typical overgeneralization errors like 'eated' or 'drinked' was also included in order to gain information on the child's morphological productivity which is considered as sign of development at this age.

After a small-scale pilot study, we started a large-sample norming study to lay the foundations of a screening procedure based on the HCDI-III. The aims of the current study were:

- to explore the relevant psychometric properties of the instrument;
- to identify factors characteristic of the families and children such as age, gender, birth weight, birth problems, number of siblings, birth order, multilingualism, parents' education, net income, and chronic illness that are related to language development at the age group under investigation; and
- to determine cut-off scores for the purpose of screening LD in kindergarten at the age of 3 years.

TABLE 1 Distribution of the normative sample according to mother's education

Mother's education	*N*	%
Primary school	25	1.8%
Vocational training	67	4.7%
Vocational secondary school/grammar school	318	22.3%
College/university	987	69.3%
No data available	27	1.9%
Total	1424	100%

TABLE 2 Distribution of the normative sample according to the per capita income of the family (in Hungarian forints (HUF) and approximate euro amounts)

Familial income per capita	*N*	%
< HUF 50,000 (< €150)	109	7.7%
Between HUF 50 and 100,000 (€150–300)	425	29.8%
Between HUF 100 and 150,000 (€300–450)	347	24.4%
Between HUF 150–200,000 (€450–600)	200	14.0%
> HUF 200,000 (€600)	195	13.7%
No data available	148	10.4%
Total	1424	100%

METHOD

Recruitment

The norming study of the HCDI-III was conducted in a joint research collaboration with the Metropolitan Pedagogical Services in Budapest. The data collection took place in cooperation with its District Member Institutions (II, XI–XIV, XX and XXII districts), joined by the Gárdony Member Institution of the Fejér County Pedagogical Service, the Pécs Member Institution of the Baranya County Pedagogical Service. Parent report forms along with a demographic survey form were distributed to and recollected from parents of targeted children in kindergartens by speech and language therapists employed by the pedagogical service institutions. Parents of all Hungarian-speaking children between the ages of 2;0 and 4;2 who did not have a diagnosis of special education needs at the time of the survey have been requested to participate in the study. Parents have been informed about the purposes of the study and gave their written consent to use the data provided on the forms.

Sample characteristics

The aggregation of the returned survey forms (78.6% of distributed forms have been returned) resulted in a normative database comprising data from 1424 children aged 2;0–4;2. The gender distribution of the sample is balanced, with 51.1% boys and 48.9% girls. In terms of socioeconomic characteristics, the children of more educated parents appear to be relatively over-represented in the sample (Table 1), while the sample is more balanced in terms of the financial situation (per capita income) of the families (Table 2). For reference, according to the Population Census 2011 (Hungarian Central Statistical Office, 2012) the proportions of mothers (with at least one child) between 20 and 39 years of age by education is the following: 2.12% no education (did not finish primary school), 17% primary school, 23.73% with secondary school, 33.72% with secondary school (baccalaureate) and 23.43% with high school or a university degree. Note that a high proportion of our sample (82.9%) comes from the region of Budapest where generally more than 70% of the people finish secondary school (with baccalaureate) or obtain a college or university degree. The assumed effect of the higher proportion of more educated mothers in the sample is addressed below in the discussion.

According to parental reports, the birth weight of children in the database was less than 2500 g in 9.3%, and birth problems—such as C-section, prolonged jaundice, overdue pregnancy, buttock, preterm birth—were reported in 43.8% of children. 6.5% of children spoke a language other than Hungarian as well. 2.7% of children were reported to have some form of chronic illness, for example, asthma, food sensitivity, hypotension.

Description and scoring of the CDI-III

The HCDI-III obtains information about the language development of the children through the pre-structured, written report of their parents. The two-page parent report form includes five sections:

- Vocabulary.
- Sentences.
- Using language.
- Example sentences.
- Productive errors.

The Vocabulary section consists of a 124-item checklist in which a parent marks the words expressively used (spoken) by their child. This list has been compiled to include both words that appear more often and less frequently in the speech of 3-year-olds. The words include 49 nouns, 16 verbs, 13 adjectives, six adverbs, 14 pronouns, seven question words, seven postpositions, four auxiliary verbs, four verb modifiers and two conjunction words. At the end of this section, the parent is asked whether the child has begun producing multi-word utterances. If not, the remaining parts of the questionnaire do not need to be completed. In the Vocabulary section, all indicated words are worth 1 point, thus a total of 124 points can be awarded. The question for multi-word utterances is not scored.

In the Sentences section, the parent is requested to select one of the sentences in each of the 12 sentence pairs according to the complexity and accuracy that is most characteristic of their child's speech and most similar to it. This section assesses the level of morphosyntactic complexity of the child. Scoring the Sentences section, 0 or 1 point per sentence pair can be awarded. Within each of the sentence pairs, 0 point is given for the simpler and/or erroneous (first) sentence, and 1 point is given if the more complex and complete (second) sentence is indicated by the parent. A total of 12 points can be awarded in this section.

The Using Language section consists of 14 yes/no questions about the child's verbal communication and general understanding. Based on this section, in addition to vocabulary and sentence formation, broad communication habits and the level of language use can be measured. For each question, a Yes answer is scored 1 point and a No answer is scored 0 point, yielding a total of 14 points.

In the Example Sentences section, parents provide the three longest sentences the child has recently produced. Based on this, the level of sentence complexity can be evaluated by analysing the sentences quantitatively, for example, calculating mean length of utterance in words (MLUw) or morphemes (MLUm). In languages with rich morphology such as Hungarian, MLUm might be a more sophisticated measure of structural complexity as it reflects morpheme sequences within words rather than just phrase structure. However, since MLUm and MLUw are slightly different measures of the same data source, a high correlation between the two variables is expected. This measure can in turn be compared with the data obtained in the Sentences and Using Language sections thus revealing the level of internal reliability. MLUm and MLUw were only calculated in cases where parents provided three example sentences. However, 452 parents (31.7%) did not provide example sentences at all or could only retrieve one or two of their child's recent utterances.

In the Productive errors section, signs of morphological productivity expected to be present at the age of three are explored. Parents indicate in a brief 12-item checklist of the most frequent and typical overgeneralized word forms the ones their child produced recently and have the possibility to add their own examples. For each item indicated in the checklist 1 point is scored.

Analyses

To explore the basic psychometric properties of the instrument, we calculated correlations and partial correlations between the subtests (first taking into account, then eliminating, the effect of age). In both cases we calculated Pearson r and also Wilcox r_{pb}, but the two values were close to one another in each case therefore only Pearson correlations are presented below.[1] We also conducted curve fitting analyses to more precisely characterize the course of language development as it is measured by the subtests. To identify families' and children's characteristics (age, gender, birth weight, birth problems, number of siblings, birth order, multilingualism, parents' education, net income, and chronic illness) that are related to language development, analysis of variance (ANOVA), and multiple regression analyses were deployed. Finally, to evaluate the adequacy of the tool for the purpose of screening LD in kindergarten at the age of 3 years, we used principal component analysis (to uncover the internal structure of four out of the five subtests—the exception was MLU which does not itself consist of numerous items), and calculated reliability measures.

RESULTS

Correlations between the main variables

We calculated correlation matrices using the six main variables: *Vocabulary*, *Sentences*, *Language use* (LangUse), *MLU in morphemes* (MLUm), *MLU in words* (MLUw) and *Productive errors* (ProdErrors). These correlations were calculated based on age in months—that is, using 27 age groups (data points) formed from individual data. Thus, the data of all children between 24 and 25 months were averaged for the six main variables (separately); so was the data of subjects between 25 and 26 months, and so on, resulting in 27 data points (for the range of 24 to 50 months of age). The six variables aggregated this way deviated from normal distribution only minimally: the Kolmogorov test was not significant for any of them, however *Sentences* was significantly negatively skewed (skewness = –1.497; $p < 0.01$), and also was significantly leptokurtic (kurtosis = 2.430; $p < 0.01$).

First, we calculated the correlations of all six variables with age in months, followed by a correlation matrix between the six main variables. Finally, we partialled out the effect of age from the correlations between pairs of the six variables.

Correlations with age were high, and partials were noticeably lower than raw correlations, although still significant in most cases (Table 3). The MLUm–MLUw correlation was unaffected by partialling out age, which is not surprising given that this correlation is independent of age and development. *Productive errors* exhibited a relatively loose correlation with the other five variables, and this relationship dropped below significance as the mediatory role of age was eliminated. The other five variables were highly correlated with one another; even their partial correlations were substantial and highly significant. Table 3 summarizes the results.

Effects of age and gender

As a first glance at the effects of age and gender we conducted univariate analyses of variance on the six main variables. However, sizes of the age groups were variable, and residual SDs were unequal for three of the six main variables (Levene's test was significant for *Vocabulary*, *Sentences* and *LangUse*, but not for *MLUm*, *MLUw*, and *Productive errors*). Therefore, for *Vocabulary*, *Sentences*, and *LangUse*, Welch tests were calculated using *Age group* as independent variable (including both genders), and also for the interaction variable,[2] followed by independent *t*-tests for the effect of gender (including all age groups). Results are summarized in Table 4.

The effect of age was significant for all variables, with reasonably large effect sizes (except *ProdErrors*). In addition, there were significant gender differences to the advantage of girls for four variables (*Vocabulary*, *Sentences*, *LangUse*, *Productive errors*); however corresponding effect sizes were small. There was no interaction between age and gender for any of the variables.

Progression with age: curve estimation

Of the six main dependent variables, five showed substantial age-related increase: *Vocabulary*, *Sentences*, *Language use*, *MLU morphemes* and *MLU words*. *Productive errors*, however, was only weakly related to age. Based on age in quarters (nine groups) we calculated the median, 10th, 25th, 75th and 90th percentiles from raw data. Different curve estimation models (linear, logarithmic, inverse, quadratic, cubic, power, exponential, and logistic) were tested to find the best fit for the six variables. Quadratic or cubic models worked best for the first five variables indicating some deceleration of performance growth in the examined age range. However, none of the models gave a reasonably good fit to *Productive errors*. Figures 1–6 present the fitted curves to the first five variables, and the raw data for *Productive errors*.

TABLE 3 Correlations and partial correlations (with age partialled out) between the main variables

		Vocabulary	**Sentences**	**LangUse**	**MLU_m**	**MLU_w**	**ProdErrors**
Sentences	Pearson *r*	0.956***					
	Pearson *r*/Age	0.857**					
LangUse	Pearson *r*	0.992***	0.946***				
	Pearson *r*/Age	0.922**	0.814**				
MLU_m	Pearson *r*	0.933***	0.912***	0.940***			
	Pearson *r*/Age	0.670**	0.644**	0.724**			
MLU_w	Pearson *r*	0.932***	0.893***	0.942***	0.991***		
	Pearson *r*/Age	0.649**	0.561**	0.719**	0.962**		
ProdErrors	Pearson *r*	0.656***	0.627***	0.663***	0.619***	0.620***	
	Pearson *r*/Age	0.294	0.246	0.329	0.214	0.215	
Age (months)	Pearson *r*	0.947***	0.861***	0.953***	0.876***	0.879***	0.614***

Note: For each pair of dependent variables, Pearson's r/Age shows the correlations with the effect of age partialled out.
$^{**}p < 0.01$; $^{***}p < 0.001$.

TABLE 4 Effects of age and gender

Variable	Levene	Test used	Age		Gender		Interaction	
			Significance	Partial eta squared	Significance	Partial eta squared	Significance	Partial eta squared
Vocabulary	$p < 0.001$	Welch	$p < 0.001$	0.143	$p < 0.002$	0.006	n.s.	0.003
Sentences	$p < 0.001$	Welch	$p < 0.001$	0.108	$p < 0.001$	0.007	n.s.	0.019
LangUse	$p < 0.001$	Welch	$p < 0.001$	0.211	$p < 0.001$	0.011	n.s.	0.009
MLUm	n.s.	Two-way ANOVA	$p < 0.001$	0.092	n.s.	0.001	n.s.	0.006
MLUw	n.s.	Two-way ANOVA	$p < 0.001$	0.075	n.s.	0.001	n.s.	0.004
ProdErrors	n.s.	Two-way ANOVA	$p < 0.002$	0.019	$p < 0.05$	0.003	n.s.	0.005

Note: ANOVA, analysis of variance.

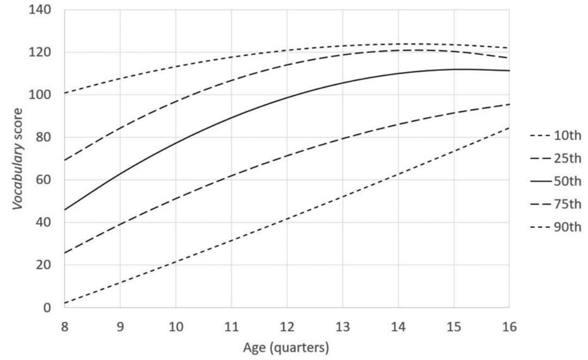

FIGURE 1 Median and percentiles for *Vocabulary*: quadratic fit

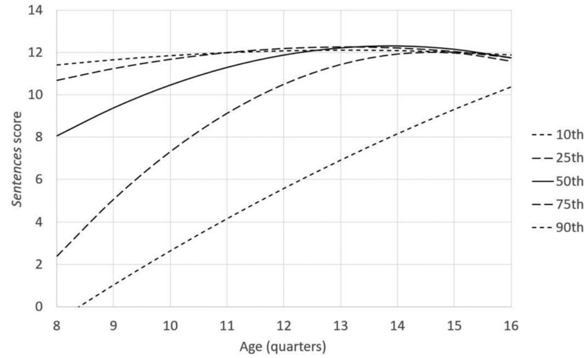

FIGURE 2 Median and percentiles for *Sentences*: quadratic fit

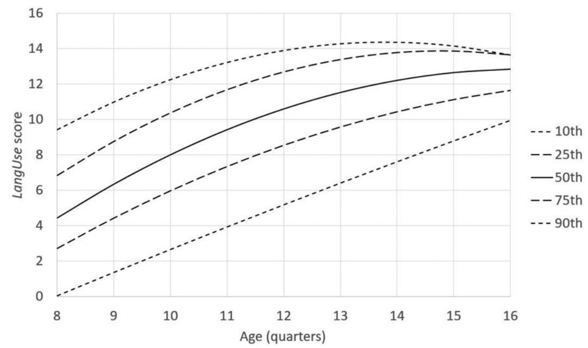

FIGURE 3 Median and percentiles for *LangUse*: quadratic fit

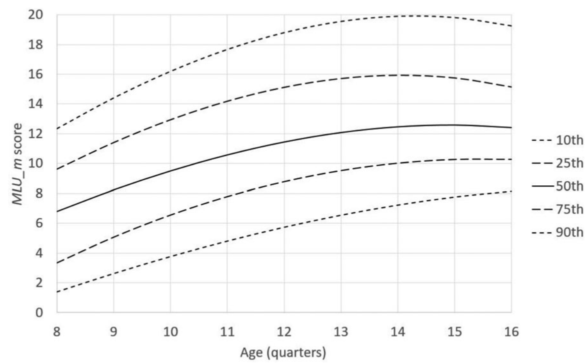

FIGURE 4 Median and percentiles for *MLUm*: cubic fit

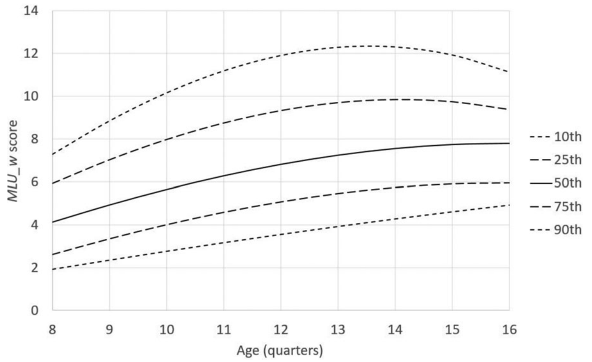

FIGURE 5 Median and percentiles for *MLUw*: cubic fit

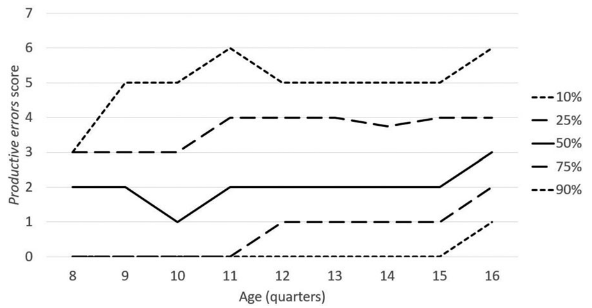

FIGURE 6 Median and percentiles of *Productive errors*: raw data

Multiple regression analyses

We examined the effect of eleven predictors on our main variables in six separate multiple regression analyses. The predictors were: age (days), gender, birth weight (below or above 2.5 kg), C-section, other birth problem, number of siblings, birth order (first born or no siblings/has older siblings), multilingual, parents' education, net income, and chronic illness. Seven of these were binary (gender, birth weight, C-section, other birth problem, birth order, multilingual and chronic illness); parents' education was scaled from 1 to 8.[3]

Of these variables the same three had a significant effect on all six dependent variables: age, gender, and parental education. Table 5 shows the results of these analyses; note that little variance in *production errors* is explained by any of the predictors.

Dimensionality analysis

Dimensionality of the four scales comprising numerous items (*Vocabulary*, *Sentences*, *Language use*, and *Productive errors*) was examined by a principal component analysis without rotation. We were looking for a single component accounting for a large amount of variance, that is, a unidimensional structure in the data (DeVellis, 2012). Reliability analysis was conducted using Cronbach's alpha and Carmines' theta (Cronbach, 1951; Carmines & Zeller, 1982).

For the Vocabulary section, principal component analysis (PCA) yielded 14 initial factors with eigenvalue over 1; and three with eigenvalue over 2 (PC1 = 47.046; PC2 = 5.577; PC3 = 2.732). The first eigenvalue being more than double of the second one is evidence of a one-dimensional structure (Hattie, 1985). Each and every word loaded highest on the first factor (factor 1); all of these values exceeded 0.4. Only eight words gave loadings larger than 0.4 on factor 2 thus explaining (non-uniquely) at least 16% of the variance in that factor. All other loadings were below 0.4. Factor 2 received 12 loadings between 0.3 and 0.4; and factor 3 received one such loading. Factor 1 accounted for 37.940% of variance in the data; factor 2 for 4.498%, and factor 3 for 2.204%. This suggests that we obtained good evidence for unidimensionality, especially so considering the large number of variables involved. The reliability assessed by Cronbach's alpha was 0.986; Carmines' theta was 0.987.

In the Sentences section, for the 12 variables involved PCA output 2 factors with eigenvalues above 1, (PC1 = 5.204; PC2 = 1.094). Each variable loaded highest on factor 1; each loading on this factor exceeded 0.4. Two items gave loadings above 0.4 on factor 2, and three more between 0.3 and 0.4. Factor 1 accounted for 43.365% of the variance whereas factor 2 accounted for 9.120%, thus a reasonable level of unidimensionality again emerged. Cronbach's alpha was 0.865 indicating good reliability; Carmines' theta was 0.881.

In the Language use section, for the 14 variables PCA extracted two factors with eigenvalues over 1, (PC1 = 5.464; PC2 = 1.119). A total of 13 out of 14 variables loaded highest on factor 1 (all loadings on this factor being between 0.5 and 0.7). One variable loaded highest on factor 2; this factor had three variables loading on it above 0.4 (one above 0.6); and one variable loading between 0.3 and 0.4). Factor 1 accounted for 39.028% of variance in the data; factor 2 accounted for 7.991%. Cronbach's alpha was 0.872, and Carmines' theta was 0.880, therefore this subtest may also be used as a one-dimensional psychometric scale.

In the Productive errors section, for the 12 variables PCA produced three factors above an eigenvalue of 1 (PC1 = 2.375; PC2 = 1.658; PC3 = 1.031). Six variables loaded highest on factor 1; four variables loaded highest on factor 2, and the remaining two variables did so on factor 3. These three groups of loadings were in the same range, mostly between 0.5 and 0.7 (with two exceptions out of 12). Factor 1 accounted for 19.794% of variance in the data; factor 2 accounted for 13.813%, and factor 3 for 8.590%. Cronbach's alpha including all items was 0.619, that is, too low for a reliable scale. Carmines' theta was 0.631. Thus, unidimensionality did not obtain for this subtest. However, the

TABLE 5 Effect of demographic predictors on the main variables

Dependent	Predictor	*B*	SE *B*	Beta	Adjusted-R^2	Significance	*N*
Vocabulary							1220
	AgeDays	0.074	0.005	0.393	0.150	$p < 0.001$	
	ParentEd	3.115	0.629	0.129	0.017	$p < 0.001$	
	Gender	5.217	1.650	0.082	0.007	$p < 0.01$	
Sentences							1218
	AgeDays	0.006	0.001	0.317	0.096	$p < 0.001$	
	ParentEd	0.389	0.067	0.155	0.024	$p < 0.001$	
	Gender	0.639	0.176	0.097	0.009	$p < 0.001$	
LangUse							1220
	AgeDays	0.010	0.001	0.471	0.217	$p < 0.001$	
	ParentEd	0.319	0.068	0.117	0.014	$p < 0.001$	
	Gender	0.684	0.179	0.096	0.008	$p < 0.001$	
MLUm							972
	AgeDays	0.010	0.001	0.305	0.087	$p < 0.001$	
	ParentEd	0.856	0.124	0.206	0.047	$p < 0.001$	
	Gender	0.674	0.325	0.062	0.003	$p < 0.05$	
MLUw							972
	AgeDays	0.010	0.001	0.305	0.076	$p < 0.001$	
	ParentEd	0.856	0.124	0.206	0.049	$p < 0.001$	
	Gender	0.674	0.325	0.062	0.002	n.s.	
ProdErrors							1220
	AgeDays	0.001	0.000	0.116	0.012	$p < 0.001$	
	ParentEd	0.137	0.043	0.091	0.007	$p < 0.002$	
	Gender	0.241	0.112	0.061	0.003	$p < 0.05$	

three factors that arose in PCA are relatively easy to interpret. Each of the six items that loaded highest on factor 1 tested different forms of attaching the accusative suffix.[4] Of the four variables that loaded highest on factor 2, three were past tense markings of verbs (*eszett; iszott; alszott*); the fourth was a test of forming a possessive pronoun (*tiem*)—thus factor 2 seems associated with past tense acquisition for the most part. Factor 3 had highest loadings from two items, one of which involved a noun in genitive case (*apája*), and the other a conjugated verb in third person singular (*olvasi*). For factor 1 Cronbach's alpha was 0.662, still lower than acceptable in our opinion; for factor 2 it was only 0.412 (0.547 if the three past tenses only were included); finally for factor 3 it was 0.180.

To summarize, the relative disorganization of the Productive errors section (1) may explain its low correlations with the other five scales; and (2) raises questions about its applicability as a psychometric scale, in its present form.

Screening for LD

The criteria used in the process of screening for LD are based on the thresholds calculated from the data in Table 6 (descriptives). We used only the scores of the main three sections (Vocabulary, Sentences and Language use) that proved to be unidimensional and were reliably filled out by most of the parents. We excluded Productive errors and MLU for these reasons and use them only as additional information for clinical characterisation. For each age group, 1.25 times the standard deviation is subtracted from the mean score of the three main sections (Vocabulary, Sentences and Language Use) yielding a cut-off score for each section by age group for the purposes of the screening roughly corresponding to the 15th percentile for most sections and age groups. As cut-off scores (mean = 1.25 SD) in the Sentences and Language use sections in the first two age groups (between 24–26 and 27–29 months) are close to zero, these sections are judged not to be appropriate for children younger than 30 months. Therefore, the instrument is only suggested to be used for screening between 30 and 50 months of age.

Individual scores falling below the threshold (mean = 1.25 SD) in either section are considered to indicate LD. As discussed above, LD can take many different forms. For some children, it is manifested mainly in the domain of vocabulary, whereas others experience difficulties at more complex levels such as sentence formation or use of language in context which may be reflected in low scores in the Sentences of Language use sections. Therefore, results below the cut-off score in any of the three main sections (Vocabulary, Sentences and Language Use) indicates the suspect of LD and a need for assessment by a speech and language therapist. Cut-off scores for each section in each age group are provided for SLTs in the scoring manual of the form. According to these criteria, 74 children (5.2%) fell below the cut-off score in all three sections, an additional 63 children (4.4%) did so in any two out of three sections whereas another 129 children (9.1%) achieved a low score in only one of these sections. If we only consider Vocabulary being the most robust section of the form, the proportion of children scoring below the screening threshold varies from 14.9% (26–28-month-olds) to 10.8% (48–50-month-olds). Severity of the language difficulty in an individual child is reflected in the number of sections showing scores under the screening threshold. Thus, the 9.6% of children achieving below the cut-off levels in at least two sections are considered to exhibit more severe difficulties affecting more than one domain of language.

DISCUSSION

Our study aimed to present the adaptation process and norming data of the Hungarian version of the MacArthur–Bates CDI-III in order to lay the foundations of a screening tool for LD in the country. The HCDI-III has been constructed as an adaptation of the original US version (Dale et al., 2001; Fenson et al., 2007) with a number of significant modifications and expansion in the vocabulary part. The norming study included 1424 children (51.1% male) aged 2;0–4;2. Guidelines for scoring all sections of the HCDI-III has been provided and six outcome variables have been created to cover the domains of expressive vocabulary, morphosyntax, and language use. Statistical analyses revealed appropriate psychometric properties of five outcome variables that showed normal distribution and were strongly correlated to age. Outcomes of girls were slightly (but significantly) higher on scales corresponding to vocabulary, syntax, language use, and productivity. Most variables were highly correlated with one another even with age partialled out. These results are in concordance with the literature and thus support the validity of the HCDI-III until direct tests of validity and reliability will be put forward. At this time we have not studied the classification accuracy of the instrument, which is one of our priorities for future research.

The results support the eligibility of the instrument for screening purposes. Vocabulary, Sentences, Language Use, MLUw and MLUm show a predictable progression with age while Productive errors are only weakly related to age. Thus, five out of six variables can be used adequately for judging children's language skills based on age norms up to 4 years of age. However, the expected minimal achievement for typical development based on the mean and standard deviation below 30 months of age in the Sentences

TABLE 6 Descriptive data of the CDI-III sections

					95% Confidence interval			
	Age (year;months)	**Mean**	**SD**	**SE_{mean}**	**Lower bound**	**Upper bound**	**Minimum**	**Maximum**
Vocabulary	2;0–2;2	45.621	31.430	5.836	34.182	57.060	0	111
	2;3–2;5	64.516	35.012	4.447	55.801	73.231	0	124
	2;6–2;8	68.782	35.587	3.262	62.388	75.175	0	124
	2;9–2;11	82.343	31.340	2.678	77.095	87.591	0	124
	3;0–3;2	90.335	30.726	2.157	86.108	94.562	0	124
	3;3–3;5	93.654	30.794	1.867	89.995	97.314	0	124
	3;6–3;8	97.950	27.169	2.019	93.992	101.908	0	124
	3;9–3;11	101.727	26.290	2.996	95.855	107.599	0	124
	4;0–4;2	108.025	14.039	2.220	103.674	112.376	76	124
Sentences	2;0–2;2	6.241	4.223	0.784	4.704	7.778	0	12
	2;3–2;5	8.177	4.055	0.515	7.168	9.187	0	12
	2;6–2;8	8.101	4.406	0.404	7.309	8.892	0	12
	2;9–2;11	10.205	3.313	0.283	9.650	10.760	0	12
	3;0–3;2	10.385	3.241	0.227	9.939	10.831	0	12
	3;3–3;5	10.438	3.130	0.190	10.066	10.809	0	12
	3;6–3;8	11.072	2.474	0.184	10.711	11.432	0	12
	3;9–3;11	10.909	2.848	0.325	10.273	11.545	0	12
	4;0–4;2	11.325	2.030	0.321	10.696	11.954	0	12
LangUse	2;0–2;2	4.241	2.849	0.529	3.204	5.278	0	11
	2;3–2;5	7.048	4.174	0.530	6.009	8.087	0	14
	2;6–2;8	6.983	3.714	0.340	6.316	7.651	0	14
	2;9–2;11	8.934	3.448	0.295	8.357	9.512	0	14
	3;0–3;2	10.148	3.178	0.223	9.711	10.585	0	14
	3;3–3;5	10.765	3.308	0.201	10.372	11.158	0	14
	3;6–3;8	11.055	3.064	0.228	10.609	11.502	0	14
	3;9–3;11	11.442	3.346	0.381	10.694	12.189	0	14
	4;0–4;2	12.000	2.542	0.402	11.212	12.788	0	14

(Continues)

TABLE 6 (Continued)

	Age (year;months)	Mean	SD	SE_{mean}	95% Confidence interval		Minimum	Maximum
					Lower bound	Upper bound		
MLUm	2;0–2;2	7.121	4.411	0.819	5.515	8.726	0	18.5
	2;3–2;5	8.884	4.955	0.629	7.651	10.118	1	23.33
	2;6–2;8	8.777	4.688	0.430	7.935	9.619	0	21.67
	2;9–2;11	11.401	5.388	0.460	10.498	12.303	0	31.5
	3;0–3;2	12.562	5.549	0.389	11.799	13.326	0	34
	3;3–3;5	12.669	5.474	0.332	12.018	13.319	0	39
	3;6–3;8	12.944	4.867	0.362	12.235	13.653	0	29
	3;9–3;11	13.325	5.700	0.650	12.052	14.598	0	30.5
	4;0–4;2	12.517	4.341	0.686	11.172	13.863	1	22.67
MLUw	2;0–2;2	4.531	2.434	0.452	3.645	5.417	0	9.5
	2;3–2;5	5.583	2.879	0.366	4.866	6.300	1	14
	2;6–2;8	5.589	2.897	0.266	5.069	6.110	0	13
	2;9–2;11	7.027	3.361	0.287	6.464	7.590	0	20
	3;0–3;2	7.668	3.443	0.242	7.195	8.142	0	21.67
	3;3–3;5	7.757	3.455	0.209	7.347	8.168	0	20.25
	3;6–3;8	7.885	3.127	0.232	7.430	8.341	0	17
	3;9–3;11	8.164	3.676	0.419	7.343	8.985	0	19
	4;0–4;2	7.737	2.715	0.429	6.896	8.579	1	14
ProdErrors	2;0–2;2	1.586	1.376	0.256	1.085	2.087	0	4
	2;3–2;5	1.984	1.815	0.231	1.532	2.436	0	7
	2;6–2;8	1.866	1.926	0.177	1.519	2.212	0	7
	2;9–2;11	2.482	2.263	0.193	2.103	2.861	0	9
	3;0–3;2	2.567	1.965	0.138	2.296	2.837	0	10
	3;3–3;5	2.585	1.917	0.116	2.357	2.812	0	8
	3;6–3;8	2.354	1.828	0.136	2.087	2.620	0	10
	3;9–3;11	2.506	2.037	0.232	2.052	2.961	0	8
	4;0–4;2	2.800	2.301	0.364	2.087	3.513	0	10

and Language use sections is too low for being appropriate for a screening threshold. Therefore, the instrument is only suggested to be used for screening between 30 and 50 months of age. Different calculations of MLU in words or morphemes correlated highly with each other and show very similar age trends and relationship with the other variables. Therefore, although analysing the morphological structure of the words in children's sentences might provide additional information about the child's morphosyntactic skills, using only MLU in words for characterisation of children is justified by the data. However, as a substantial proportion of parents do not reliably cite three utterances from their child in the form, the criteria of screening for LD do not include MLU.

The proportion of children selected with probable LD is comparable to those reported by Dale et al. (2003) who classified 10.7% of 3-year-old and 11.5% of 4-year-old children with LD using the 15th centile criterion in at least two out of three subparts of the CDI-III (Dale et al., 2003). To support the validity of the screening in clinical practice, it is suggested that the SLT evaluating the parent report forms consult with the kindergarten teacher about each child in her group concerning the screening result. Controversy between the kindergarten teacher's opinion and the scores of the CDI-III might indicate false negatives or false positives and requires assessment of an SLT using standard measures of language abilities. The assessment also creates the possibility to gather information concerning the relevant risk factors from the parents to support the accuracy of the clinical decision to be made.

Multiple regression analyses revealed significant effect of age, gender and parental education on all main outcome variables. The effect of parental education (a factor of SES) is in line with the majority of CDI studies suggesting differences in language skills between 3-year-old children coming from different cultural backgrounds with the exception of the Swedish study (Eriksson, 2017). The effect of gender favouring females is also replicated here. However, neither one of the other eight predictors including familial and birth-related factors affected linguistic outcomes in our sample. This result is in contrast with many studies identifying various perinatal risk factors (e.g., prematurity, birth difficulties, and low birth weight) as potential risk factors for speech and language difficulties (Wallace et al., 2015; Rudolph, 2017; Zambrana et al., 2014).

Dimensionality and reliability analyses of the 4 scales comprising numerous items (*Vocabulary*, *Sentences*, *Language use* and *Productive errors*) revealed good evidence for unidimensionality and reliability for three scales, so *Vocabulary*, *Sentences* and *Language use* can be used as one-dimension psychometric scales. This is, however, not the case for Productive errors, due to a relative disorganization of its items. Thus, this section should not be used as a norm-based scale for screening purposes, still it may carry significant qualitative information signalling productive morphology through the presence of overgeneralization errors.

Based on the results, the HCDI-III has been introduced to clinical practice in Hungary and proved to be a cost-effective and appropriate instrument administered by speech and language therapists in preschool settings. As it is discussed above, the current Hungarian regulation foresees mandatory screening in children over 3 years entering kindergarten, which typically takes place between the ages of 3 and 4 in practice. Therefore, screening with the HCDI-III focuses on children at or above 3 years of age and the normative data of children below 3 years can be used as a reference for judging the level of difficulty in older children. The suggested diagnostic procedure includes informing and consent of parents, transfer and recollection of the questionnaires, scoring and norm-based evaluation. Parents have the opportunity to fill out the HCDI-III form either in a hardcopy or in a web-based platform hosted by the Educational Services Centre. Clinical judgment is recommended to rely on the HCDI-III data as well as a consultation with the kindergarten teachers and personal observations and subsequent assessments by the speech and language therapist. The HCDI-III is also administered as part of an assessment procedure monitoring the progress of development typically after a semester or a year of the chosen form of early intervention.

Due to the nature of the parent form method and the characteristics of the sample presented above, some limitations of the study can be identified. Our sample consists of a considerably higher proportion of higher educated mothers than the Hungarian population overall, due to the focus on the region of Budapest and the voluntary basis of participation during the data collection. As parental education is related to children's language outcomes in numerous studies discussed above including ours, it is assumed that the proportion of children with LD might be higher in regions where overall educational levels are lower and low-SES families are more frequent. As the cut-off scores for screening is based on data coming from a sample of children with relatively higher educated mothers, children with less educated parents and those from low-SES families and are more likely to score below the screening threshold. This might increase the proportion of children classified as LDed in certain regions. However, as LDs identified at 3–4 years are more reliably reflect persistent difficulties affecting later academic and social development, a higher number of potentially false positive screening results (and less false negatives) is acceptable as it was also claimed by Law and Roy (2008) and Westerlund et al. (2006). Subsequent standardized assessments can clarify whether the individual child exhibit severe difficulties requiring intervention.

Another set of shortcomings of the HCDI-III corresponds to the parent report format that limits measuring receptive language skills and its applicability and validity depends on a good rapport and collaboration with lay parents. According to Fenson et al. (2007) parents cannot reliably judge their children's receptive abilities from the age of 18 months. Therefore, items concerning receptive abilities are not included in the parent form although comprehension difficulties indicate more severe forms of language disorders and thus would be important to identify as early as possible. The lack of receptive measure can be compensated for by the SLT's direct assessments based on the screening outcomes. As for the required collaboration with parents, those with obvious limitations including low educational achievement (low-SES) or unavailability due to working conditions, hospitalization or mental health conditions (e.g., depression) should be identified and approached in a different way. Screening must be put forward even if the collaboration with the parents is limited or cannot be achieved. As an alternative, supplementary adult report forms for kindergarten teachers might provide standardized judgments of children's communicative skills in the preschool group in these circumstances. As rural regions of Hungary are characterized by a higher prevalence of low-SES families, more research is needed to establish the screening procedure and subsequent measures adapted to their needs.

NOTES

[1] Wilcox robust correlation coefficients tend to eliminate the effect of outliers from linear correlation. In no case did we find Wilcox's r_{pb} being substantially lower (or higher) than Pearson's r. The maximum such difference was -0.048: for *ProdErrors* and *Vocabulary*, r was 0.656, whereas r_{pb} was 0.608, both significant at $p < 0.001$. This suggests that Pearson coefficients in the present case are not influenced by outliers, hence they are suitable for characterizing correlations between our variables.

[2] For each of the three variables affected, the interaction variable was calculated using the formula:$\mathrm{IA}_{ijk} = x_{ijk} - \mathbf{x}_{i..} - \mathbf{x}_{.j.} + \mathbf{x}_{...}$,where text in bold refers to means; i tends from 1 to 2 for *Gender*, and j tends from 1 to 9 for *Age group*. That is, from each subject's measured value we subtracted the row mean (weighted mean of both genders in the age group in question), then the column mean (weighted mean of all age groups within a gender) and then added to it the grand mean to obtain the subject's interaction value. On these interaction variables a robust one-way ANOVA (Welch) was conducted using an independent variable with $2 \times 9 = 18$ levels.

[3] Both parents were scaled from 1 to 4, and the two scores added. The four levels were: 1, grade school (elementary, 8 years); 2, vocational school without a baccalaureate; 3, high school with a baccalaureate; and 4, higher education (college or university). The justification for using this independent variable (instead of eight binary ones) was that it proved a significant predictor for each of the six dependent variables.

[4] The accusative case is marked uniformly with a -t suffix in Hungarian; however, there is a great deal of not well predictable variability in how that suffix is attached to the noun. For some nouns ending with a vowel, the -t is simply added to the word ending; in other cases, vowels or entire syllables are inserted between the two. An example illustrating the unpredictability is the pair of nouns *ló* (horse) and *só* (salt); the accusative of the former is *lovat* (syllable -va- inserted) whereas that of the former is *sót* (simple addition). This causes an extended course of acquisition in language development for the accusative suffix.

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