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The Adult Reading History Questionnaire (ARHQ) in Icelandic: Psychometric Properties and Factor Structure

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Abstract

This article describes psychometric testing of an Icelandic adaptation of the *Adult Reading History Questionnaire* (ARHQ), designed to detect a history of reading difficulties indicative of dyslexia. Tested in a large and diverse sample of 2,187 adults, the Icelandic adaptation demonstrated internal consistency reliability (Cronbach's alpha = .92) and test–retest reliability (r = .93). Validity was established by comparing scores of adults who as children received ICD-10 diagnoses of specific reading disorder (F81.0; n = 419) to those of adults defined as nondyslexics (n = 679). ROC curve analysis resulted in an area under the curve of .92 (95% CI = .90, .93, p < .001) and a cutoff score of .43 with sensitivity of 84.5% and specificity of 83.7%. An exploratory factor analysis (n = 2,187) suggested three subscales, Dyslexia Symptoms, Current Reading, and Memory, the mean scores of which differed significantly among diagnosed dyslexics, relatives of dyslexics, and population controls. Our results support the applicability of the ARHQ in Icelandic as a self-report screening tool for adult dyslexia in Iceland.

Keywords

adult dyslexia, screening, *Adult Reading History Questionnaire*, Iceland

Dyslexia is one of the most frequently diagnosed childhood disorders in literate parts of the world, with prevalence estimates ranging between 5% and 10% depending on the diagnostic criteria used, populations sampled, and languages spoken (Vellutino, Fletcher, Snowling, & Scanlon, 2004). A similar prevalence may be seen in Iceland, where up to 10% of the population experience reading difficulties despite adequate education (Marinosson, Asbjornsson, Halldorsson, & Kristinsdottir, 1997). Although considerable advances have been made in understanding the cognitive, behavioral, and biological deficits associated with dyslexia, its etiology remains largely unknown (Vellutino et al., 2004). While most experts believe that dyslexia is a complex heritable trait, it has proven difficult to find variants in the sequence of the genome associated with the risk of dyslexia (Vellutino et al., 2004; Williams & O'Donovan, 2006). To date, there has been only one genome-wide significant finding in dyslexia, one that associates mismatch negativity (reflecting automatic speech deviance processing that is altered in dyslexic children) with a variant in the *SLC2A3* gene (Roeske et al., 2011). Using such highly specific phenotypes is one approach to teasing apart the genetic underpinnings of complex disorders such as dyslexia. Another approach is to employ more inclusive and broader phenotypes, thereby increasing sample size and power. This approach has the additional advantage of being less dependent on a priori assumptions about the nature of the disorder and was used to recruit participants for an Icelandic study on the genetics of dyslexia. The study recruited three groups of participants: individuals with a confirmed diagnosis of specific developmental disorder of scholastic skills (F81) according to the ICD-10 (*International Classification of Diseases*, 10th edition) diagnostic criteria (World Health Organization [WHO], 1992) and, because of the high heritability estimates of dyslexia (up to 65%; Hawke, Wadsworth, & DeFries, 2006), their undiagnosed first- and second-degree relatives. A third, general population control

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group was also recruited. As dyslexia is reportedly underdiagnosed in Iceland, especially among adults (Marinosson et al., 1997), an easily administered, self-report measure was required to screen for possible dyslexia among adult relatives and controls. In the absence of existing Icelandic measures, we reviewed screening instruments published at the time and selected one that had been shown to be reliable and valid. Hence, the *Adult Reading History Questionnaire* (ARHQ) by Lefly and Pennington (2000) was translated to Icelandic and used within the genetic study. This is the first report on tests of validity and reliability of the Icelandic translation of the ARHQ among 2,187 adults who had completed the ARHQ at the time of this analysis.

Dyslexia in Iceland

Dyslexia is considered underdiagnosed in Iceland, and its prevalence is uncertain. As in most parts of the world, the history of formally diagnosing and treating learning disorders such as dyslexia is relatively short in Iceland. In the past 30 years or so, much improvement has been made in referring children who have unexpected difficulty learning to read despite intelligence, motivation, and education, for psychological evaluation so that their special needs can be met within the educational system (Marinosson et al., 1997). Few formal studies have, however, been conducted on adult dyslexia in Iceland, partly because of the lack of adult-appropriate measures (Marinosson et al., 1997). Hence, epidemiological data on dyslexia in Iceland are not readily available.

Diagnoses of childhood learning disabilities in Iceland are mainly guided by the diagnostic criteria of WHO's (1992) ICD-10, which are comparable to the guidelines of the American Psychiatric Association's (1994) *Diagnostic and Statistical Manual of Mental Disorders*. Accordingly, dyslexia (ICD-10 Code F81.0, specific reading disorder, under Code F81, specific developmental disorder of scholastic skills) is diagnosed when standardized tests of reading achievement are below expectations when considering age, education, and measured intelligence (IQ; WHO, 1992). Furthermore, reading performance should not be explained by defects in visual or hearing acuity nor neurological disorders other than dyslexia (WHO, 1992). These discrepancy criteria have been questioned for appropriateness when diagnosing adults, especially with regard to the importance of IQ measurements (Swanson & Hsieh, 2009). Additional criticism comes from studies showing that although many symptoms of childhood dyslexia persist over the life span, there is evidence that characteristics of dyslexia change considerably with age, adult dyslexics often demonstrating adaptive compensations induced by continued exposure to written text, education, and motivation to learn (Fink, 1998; Lefly & Pennington, 1991, 2000). Compensated dyslexic adults may therefore no longer meet the childhood criteria of dyslexia but continue to have significant difficulties in complex and prolonged reading and writing tasks that can adversely affect their lives in terms of self-esteem and possibly leading to discontinuation of advanced studies when increased reading requirements exceed compensatory mechanisms (Griffiths & Frith, 2002; Lefly & Pennington, 1991). In highly technological societies such as Iceland, where more than 90% of the population uses computers and the Internet for information processing and communication (Iceland Statistics, 2010), adult education and employment have become increasingly dependent on text processing. It may be assumed that a substantial number of adult students, especially those who discontinue advanced studies, have undiagnosed dyslexia. Academic institutions may aspire to meet the needs of these students but lack the tools with which to detect the problem. Spelling errors and slow reading detected by teachers may indicate dyslexia; however, using well-researched screening instruments is a more objective approach, while also practical in terms of cost and time.

Language may also affect the presentation and hence diagnosis of dyslexia. Diagnostic criteria for dyslexia are based on evidence from studies mostly conducted in English-speaking countries (Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Korne, 2003). Yet, studies suggest that reading skills develop differently in the English language, which is regarded a deep orthography, than in shallower European orthographies, such as Icelandic (Seymour, Aro, & Erskine, 2003). However, a cross-linguistic comparison of dyslexic children with a first language of either English or German (a shallow orthography) found more similarities than differences between the dyslexic readers of different orthographies, leading the authors to conclude that dyslexia research using the English language can indeed be generalized to other and shallower orthographies such as is Icelandic (Ziegler et al., 2003). Hence, the valid and reliable ARHQ developed in English by Lefly and Pennington (2000) was translated to Icelandic and administered to adult participants in the genetic study to detect a reading history indicative of dyslexia.

The Adult Reading History Questionnaire (ARHQ)

Few psychometrically sound instruments have been developed to screen for adult dyslexia, and even fewer have been designed for self-report. Although there exist comprehensive adult screening measures such as the *Dyslexia Adult Screening Test*, developed by Nicolson and Fawcett (1998) in the United Kingdom, these generally involve a battery of tasks, require individual administration, take considerable time, and are costly when evaluating large groups. Short self-report measures are more feasible for screening in academic settings and in large-scale research.

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Furthermore, studies in various language environments have found that adults can reliably report on their childhood reading difficulties and that such self-reports are associated with valid measures of dyslexic symptoms (Finucci, Whitehouse, Isaacs, & Childs, 1984; Lefly & Pennington, 2000; Schulte-Korne, Deimel, & Remschmidt, 1997; Wolff & Lundberg, 2003).

The ARHQ is a 23-item self-report measure developed by Lefly and Pennington (2000). It is a revised version of a 13-item adult reading history questionnaire by Finucci et al. (1984) that translated the concept of reading skill below expectation, as defined by diagnostic criteria, into an objective and quantitative procedure for classification of adult dyslexics (Finucci et al., 1984). Building on this work, Lefly and Pennington (2000) added items derived from their clinical and research experience with dyslexic adults on learning letter names, learning to spell, reading speed, effort needed to succeed, and verbal short-term memory.

Each item on Lefly and Pennington's (2000) ARHQ is responded to with a 5-point Likert-type scale ranging from 0 to 4, resulting in a score range of 0 to 92. The total score is divided by the maximum possible score (92) to generate a percentage score ranging from 0 to 1. Higher scores represent greater reading difficulties. Their tests of the ARHQ demonstrated internal consistency (Cronbach's alpha greater than .90 in two samples) and test–retest reliability (3-year interval = .81–.84; Lefly & Pennington, 2000). Furthermore, ARHQ scores were highly correlated with tests of adult reading ability (r = .70) and measures of dyslexia in childhood (r = .75; Lefly & Pennington, 2000). A discriminant function analysis using total ARHQ scores to predict a diagnosis of reading disability revealed a cutoff score of .40 with a sensitivity of 81.8%, specificity of 77.5%, and overall correct classification rate of 79% (Lefly & Pennington, 2000).

The ARHQ has since been used to determine a history of reading difficulties indicative of dyslexia among adults in various research contexts. Pennington and Lefly (2001) used ARHQ scores to determine parental dyslexia and accordingly classify the parents' kindergarten children at high (n = 67) and low (n = 57) familial risk. Having a parent with ARHQ-defined dyslexia increased children's risk of dyslexia 5.7 times over children with nondyslexic parents (Pennington & Lefly, 2001). Another study similarly used the .40 cutoff to establish parental dyslexia and determine family risk, also finding that risk of dyslexia was significantly greater among children in families where one or both parents scored above the cutoff than in families with both parents scoring below the cutoff (Friedman, Chhabildas, Budhiraja, Willcutt, & Pennington, 2003). Not only do these studies provide evidence of the familial nature of dyslexia, they also support the use of the ARHQ as a screening measure for dyslexia among previously undiagnosed adults.

Apart from the original ARHQ study by Lefly and Pennington (2000), no further psychometric tests of the measure were identified in the English language. The ARHQ has, however, been tested in several translated adaptations. A Swedish study used a subset of ARHQ items along with a battery of phonological processing tasks to develop a screening test for adult dyslexia (Wolff & Lundberg, 2003). Participants were students attending courses designed for adults with reading disabilities (most with childhood diagnoses of dyslexia; n = 50) and a control group of adult students with a history of school failures, although not related to reading (defined as nondyslexic; n = 67; Wolff & Lundberg, 2003). Results showed that of the various tests included in the screening battery, the self-report score emerged as the most powerful discriminator between the groups (Wolff & Lundberg, 2003). This study also reported results of a principal component analysis indicating two clear components, one related to dyslexia symptoms (14 items, alpha = .84) and the other to reading interest (6 items, alpha = .81; Wolff & Lundberg, 2003). This Swedish study did not report which ARHQ items were used or mean percentage scores, preventing further comparisons.

A German translation of the ARHQ was used among parents of kindergarten children in Switzerland to establish family risk of dyslexia (Maurer, 2005). Significant differences were found between 32 parents who self-reported dyslexia (M = 0.48, SD = 0.14) and 29 parents who, according to self-report, were not dyslexic (M = 0.27, SD = 0.11; Maurer, 2005). Reliability coefficients were not reported.

Finally, a Portuguese translation of the ARHQ was tested in a study of 311 adult students enrolled in a continuing education program, demonstrating internal consistency in both basic and secondary-level adult education groups (Cronbach's alpha = .83 and .84, respectively) and a significant relationship between higher ARHQ scores and poorer scores on a spelling test (r = –.37 and r = –.34); the results, however, fell short of establishing adequate validity (Alves & Castro, 2005).

The reviewed studies demonstrate that the ARHQ holds promise as a valid and reliable measure of adult dyslexia in different countries, cultures, and educational and linguistic contexts. However, most samples studied have been small, and the validity criteria and the definition of dyslexia have varied considerably between studies.

Aims

Using data gathered within the context of a study on the genetics of dyslexia in Iceland, the specific aims of the present study were to submit the Icelandic translation of the ARHQ to psychometric testing in a large, diverse sample of adults, to evaluate its performance as a screening measure for adult dyslexia in Iceland by comparing it to a gold standard of uniform F81.0 (specific reading disorder or dyslexia)

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Table 1. Demographics and Descriptive Statistics for Recruitment Groups (Upper Table) and of These, Study Groups With Complete ARHQ Data Used in the Present Study (Lower Table).

	Familial (*n* = 1,598)		Nonfamilial (*n* = 762)	Total
	Diagnosed (F81; *n* = 493)	Undiagnosed relatives (*n* = 1,105)	Controls (*n* = 762)	Total (*n* = 2,360)
Males *n* (%)	254 (51.5)	427 (38.6)	278 (36.5)	959 (40.6)
Females *n* (%)	239 (48.5)	678 (61.4)	484 (63.5)	1,401 (59.4)
Age *M* (*SD*)	26.6 (7.1)	44.9 (12.5)	45.4 (10.7)	41.2 (13.4)
Education years *M* (*SD; n*)	12.9 (2.9; 447)	13.9 (3.1; 1,035)	14.5 (3.1; 560)	13.8 (3.1; 2,042)
Complete ARHQs *n* (%)	**458 (92.9)**	**990 (89.6)**	**739 (97.0)**	**2,187 (92.7)**
Males *n* (%)	237 (51.7)	389 (39.3)	266 (36.0)	892 (40.8)
Females *n* (%)	221 (48.3)	601 (60.7)	473 (64.0)	1,295 (59.1)
Age *M* (*SD*)	26.5 (6.8)	44.3 (12.3)	45.5 (10.8)	41.0 (13.1)
Education in years *M* (*SD; n*)	12.9 (2.9; 415)	14.0 (3.1; 933)	14.4 (3.1; 539)	13.9 (3.1; 1,887)
Dyslexia (F81.0) *n* (%)	419 (91.5)			
Do you have dyslexia?				
Yes *n* (%)	411 (89.7)	80 (8.1)	51 (6.9)	542 (24.8)
No *n* (%)	37 (8.1)	887 (89.6)	679 (91.9)	1,603 (73.3)
Don't know *n* (%)	10 (2.2)	23 (2.3)	9 (1.2)	42 (1.9)

Note. ARHQ = *Adult Reading History Questionnaire*.

diagnoses as defined by ICD-10 criteria, and to establish a cutoff score for best predicting a formal diagnosis of dyslexia.

Method

Participants

Table 1 presents descriptive and demographic data for the 2,360 adult participants recruited at the time of this analysis and who had returned surveys including the translated ARHQ. Diagnosed adults (*n* = 493) were defined from index cases recruited for the genetic study on the basis of, as children or adolescents, having received any ICD-10 diagnosis of specific developmental disorder of scholastic skills (F81) and having reached the age of 18 years at recruitment. On average, diagnosed adults had received their F81 diagnoses 12.7 years (*SD* = 3.7) prior to recruitment. All were diagnosed by the same Icelandic specialist in developmental neuropsychology (second author). Most were referred for evaluation by the Icelandic school system, and mean age at diagnosis was 15.5 years (*SD* = 7.5). For the present study, exclusion criteria for the diagnosed adult group were first language other than Icelandic, IQ lower than 85, serious neurological problems, uncorrected auditory or visual acuity, and documentation of any other sources of learning difficulties predominantly because of emotional or behavioral problems. Of the 493 F81-diagnosed adults fulfilling these criteria, 419 (85%) had the main diagnosis of specific reading disorder or dyslexia (F81.0), their ARHQ results used for the validity part of the study (Table 2). The other 15% comprised individuals who, although also dyslexic, had other main diagnoses, including specific disorder of arithmetical skills (F81.2; 9%), specific spelling disorder (F81.1; 4%), or specific writing disorder (F81.8; 2%).

A total of 1,105 adult relatives of F81-diagnosed individuals completed the ARHQ; 687 (62%) were first-degree (full siblings or parents) and 418 (38%) were second-degree (half siblings, grandparents, aunts or uncles) relatives. Finally, ARHQ responses were available for 762 adults recruited for the nonfamilial general population control group. Exclusion criteria for relatives and population controls in the present study were any confirmed diagnoses of neurological disorders, including ADHD, schizophrenia, autism, and IQ lower than 85. Also excluded were individuals with a first language other than Icelandic. Of the population controls, 679 (91.9%) self-reported having neither dyslexia nor any reading or learning problems and were defined as the nondyslexic group for the validity part of the present study (Table 2).

Measures

The ARHQ was translated to Icelandic and back-translated to English according to formal instrument translation protocols. Discrepancies were examined and discussed among content and language specialists. Item 15 of the ARHQ ("Did your parents ever consider having you repeat any grades in school due to academic failure (not illness)?" was found problematic during translation, as repeating grades is

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not generally practiced within the Icelandic primary school system (Grades 1–10). Since 1980 or thereabouts, Icelandic children who demonstrate academic difficulties have been referred for testing of learning disabilities and generally advance with their age group through the elementary grades with additional academic support in the disability areas identified (Marinosson et al., 1997).

All ICD-10 diagnoses were made by the same neuropsychologist (second author) on the basis of standardized tests. These included Icelandic versions of the *Wechsler Intelligence Scale for Children* (Hannibalsson, 1971; Wechsler, 1949), *Wechsler Intelligence Scale for Adults* (Bjornsson, 1961; Wechsler, 1955), *Auditory Verbal Learning Test* (Rey, 1964; Taylor, 1959), *Rey-Osterrieth Complex Figure* (Corwin & Bylsma, 1993; Osterrieth, 1944; Rey, 1941; Taylor, 1959), *Symbol Digit Modalities Test* (Smith, 1982), standardized achievement tests of reading, spelling, and writing, and selected items from the *Luria-Nebraska Neuropsychological Battery* (Golden, 1987; Golden, Purisch, & Hammeke, 1982; Halldorsson, 1984).

Statistical Analyses

Item means and item-item correlations were examined separately in the three recruitment samples. Item 15 demonstrated very low item-total correlation, with more than 93.7% of all responses being either missing or *never* (scoring 0). The concentrated score distribution and low item-total correlations convinced us to remove this item from further analyses, which were therefore conducted on a 22-item scale we hereafter refer to as the ARHQ Iceland-adapted scale (ARHQ-Ice), with a score range of 0 to 88 points and a total score divided by 88 for a percentage score (Table 3).

To eliminate issues inherent in replacing scores for missing items (Shrive, Stuart, Quan, & Ghali, 2006), only surveys with no missing ARHQ-Ice data (n = 2,187) were used in this analysis, thereby excluding results from 173 participants, or 7.3% (Table 1). Cronbach's alpha was calculated to establish internal consistency reliability for the entire data set and for each of the three defined groups. Test–retest reliability was established in a subgroup (n = 115) of participants who answered twice, with an average of 1.6 years between surveys. The validity of the ARHQ-Ice was tested by comparing scores from individuals with a specific reading disorder diagnosis (F81.0; n = 419) to those from defined nondyslexics (n = 679; Table 2). To find the cutoff score providing the best trade-off between false negative (sensitivity) and false positive rates (1 – specificity), we applied receiver operating characteristic (ROC) curve analysis and linear discrimination (Figure 1, Table 4). To evaluate construct validity and reveal possible latent variables causing the ARHQ-Ice items to covary, an exploratory factor analysis was performed on the entire data set of ARHQ scores (n = 2,187) using the maximum likelihood method with oblique rotation (Table 5; Costello & Osborne, 2005). The study was approved by the National Bioethics Committee and Data Protection Authority in Iceland, and all participants signed informed consent. Statistical analyses were performed using SPSS 17.0.

Table 2. Demographics and Descriptive Statistics for Specific Reading Disorder (Dyslexia; F81.0) Diagnosed Individuals (n = 419) and Nondyslexic Controls (n = 679; education data available for n = 379 and n = 499, respectively).

	F81.0	Controls	Total
	n (%)	*n* (%)	*n* (%)
Males	215 (51.3)	244 (35.9)	459 (41.8)
Females	204 (48.7)	435 (64.1)	639 (58.2)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Education in years	12.8 (2.9)	14.5 (3.1)	13.8 (3.1)
Age at ARHQ	26.4 (6.8)	45.8 (10.6)	38.4 (13.3)
ARHQ-Ice	0.58 (0.15)	0.30 (0.13)	0.40 (0.19)
Age at diagnosis	18.3 (7.4)	NA	NA

Note. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.

Table 3. Descriptive Statistics for Each ARHQ-Ice Item for Surveys With No Missing Data (n = 2,187).

Item	*M*	*SD*
1	1.51	1.16
2	1.49	1.44
3	1.06	1.36
4	1.32	1.47
5	0.85	1.08
6	1.83	1.34
7	2.10	1.04
8	1.83	1.21
9	0.67	0.99
10	1.83	1.35
11	2.06	1.08
12	1.88	1.24
13	1.90	1.47
14	1.79	1.19
16	1.95	1.34
17	1.62	1.25
18	1.58	1.15
19	1.13	1.28
20	1.68	1.34
21	2.16	1.19
22	0.65	1.07
23	1.19	1.07

Note. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.

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Results

Descriptive statistics for individual items of the ARHQ-Ice are shown in Table 3. Each item had a score range from the minimum (0) to the maximum (4).

Reliability

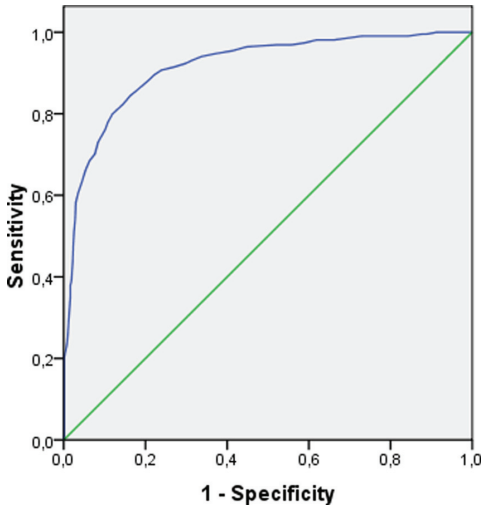
Internal consistency reliability of the ARHQ-Ice was .92 for the entire data set of complete responses (n = 2,187) and, within each recruitment group, was .88 for F81 diagnosed, .92 for relatives, and .89 for controls. All cases exceeding the accepted .80 standard for psychometric tests (DeVellis, 2012). Test–retest reliability resulted in a within-subjects correlation of .93 for measures administered on average 1.6 years apart.

Validity

Comparing ARHQ-Ice mean scores among the three recruitment groups revealed a statistically significant group effect, $F(2, 22) = 344.83$, $p < .001$. Employing the Bonferroni post hoc test, we detected significant differences in ARHQ-Ice scores among each of the recruitment groups ($p < .001$; Table 6).

Next, we performed a discriminant analysis with dyslexic status as the binary dependent variable and ARHQ-Ice scores, gender, age when answering, and years of education as predictor variables. As education data were not available for all participants, a total of 878 cases were analyzed. Univariate ANOVAs revealed that diagnosed dyslexics (F81.0) and defined nondyslexics differed significantly on each of the four predictor variables. A single discriminant function revealed significant differences of dyslexics and nondyslexics ($\chi^2 = 1009.05$, $df = 4$, $p < .001$). The correlations between predictor variables and the discriminant function suggested that age when answering the survey and ARHQ-Ice scores were the best predictors of having an F81.0 diagnosis, with age negatively correlated (–.71), indicating that older participants were less likely to be diagnosed. ARHQ-Ice scores were positively correlated (.68) with the discriminant function value, indicating that participants with higher ARHQ-Ice scores were more likely to have diagnosed dyslexia. The low correlation coefficients of gender (.02) and years of education (.04) within our sample show the very slight contribution of these variables to the discrimination between dyslexic and nondyslexic status. Overall, the discriminant function successfully predicted the outcome for 91.7% of cases, with an accurate prediction being made for 88.8% of the nondyslexics and 95.5% of the dyslexics.

To determine an ARHQ-Ice cutoff value, diagnosed dyslexic and nondyslexic groups were examined using an ROC curve analysis, employing the AUC (area under the curve) as the index of discriminant ability. The ROC curve (shown in Figure 1) follows the left-hand side and then the top border, indicating a high classification accuracy of ARHQ-Ice scores. The AUC was .92 (95% CI = .90, .93, $p < .001$). On the basis of the ROC curve analysis, we determined that classifying individuals with ARHQ-Ice scores greater than .43 as dyslexic resulted in the best balance between sensitivity and 1 – specificity. Table 4 shows the breakdown when using the .43 ARHQ-Ice cutoff compared to the formal F81.0 diagnoses; sensitivity represented by the proportion of true positives correctly identified with the cutoff (84.5%) and specificity the proportion of true negatives correctly identified by scoring below or at the ARHQ-Ice cutoff (83.7%).



Coordinates of the ROC Curve

ARHQ-Ice	Sensitivity	1-Specificity
.36	.92	.30
.37	.91	.27
.38	.91	.24
.39	.90	.22
.40	.88	.21
.41	.86	.18
.43	**.85**	**.16**
.44	.82	.14
.45	.80	.12
.46	.78	.11

Figure 1. Classification based on ROC curve analysis (diagnosed dyslexics and nondyslexics) and coordinates of the ROC curve.

Exploratory Factor Analysis

To explore the possibility of a factor structure of latent variables causing the ARHQ-Ice items to covary, the entire

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Table 4. Classification Based on Linear Discrimination Results for the .43 Cutoff Score.

ARHQ-Ice cutoff score	Dyslexic (F81.0) *n* (%)	Nondyslexic, *n* (%)	Total *n* (%)
ARHQ-Ice > .43	354 (84.5)[a]	111 (16.3)	465 (42.3)
ARHQ-Ice ≤ .43	65 (15.5)	568 (83.7)[b]	633 (57.7)
Total	419 (38.2)	679 (61.8)	1,098 (100)

Note. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.
[a]Sensitivity. [b]Specificity.

data set of ARHQ-Ice scores (n = 2,187) was analyzed by means of an exploratory factor analysis using the maximum likelihood method of factor extraction and oblique rotation (as factors were expected to correlate; Costello & Osborne, 2005). The various indicators of factorability were good; the Kaiser–Mayer–Olkin measure of sampling adequacy was .92, Bartlett's test of sphericity was significant (χ^2 = 28736.70, df = 231, p < .001), and the residuals indicated a good solution. Initially four factors with an eigenvalue greater than 1 emerged, together explaining 57% of the variance. Inspecting these factors, only one clear factor of dyslexia symptoms emerged, the other three containing too few items or not clearly interpretable. As the scree plot indicated the possibility of three factors as well as four, we reran the analysis based on a three factor solution. All 22 items loaded on one of three factors that we describe as a dyslexic symptom scale, current reading scale, and a memory scale (Table 5). Together these factors explained 51.3% of the variance. The dyslexic symptoms scale appears most robust of the three, containing 12 items (1–8, 11, 13–14, and 19), all of which loaded highly (≥ .40) on the factor. The memory scale contained only three items (16–18), the bare minimum for a factor, but it was clear conceptually and item-factor loadings were high (≥ .48). The current reading scale (Items 9–10, 12, 20–23) was the weakest of the three, as out of its seven items, four (12, 21–23) did not reach adequate factor loadings (≥ .40) according to accepted scale development standards (DeVellis, 2012). However, they had low (≤ .13) loadings on other factors, thus clearly forming a latent, albeit weak, variable representing current reading habits.

To examine the suggested factors further, we calculated these factor or subscale scores (raw total scores, not percentages as in the ARHQ-Ice total score) and performed a one-way ANOVA to test for differences in mean scores between the three defined recruitment groups of the genetic study (diagnosed, relatives, and controls; Table 6) and for the groups defined specifically for validity testing of the ARHQ-Ice or the F81.0 dyslexics and defined nondyslexics (Table 7). On all subscales, significant (p < .001) differences were found in means among the F81-diagnosed adults,

Table 5. Exploratory Factor Analysis of the 22-Item ARHQ-Ice (n = 2,187).

	Factor		
ARHQ-Ice items (excluding item 15)	1	2	3
1. Which of the following most nearly describes *your* attitude toward school when you were a child?	.444		
2. How much difficulty did *you* have *learning to read* in elementary school?	.920		–.124
3. How much extra help did *you* need when learning to read in elementary school?	.794		–.108
4. Did you ever reverse the order of letters or numbers when you were a child?	.788		.116
5. Did you have difficulty learning letter and/or color names when you were a child?	.750		
6. How would you compare your reading skill to that of others in your elementary classes?	.892		–.118
7. All students struggle from time to time in school. In comparison to others in your classes. how much did you struggle to complete your work?	.731		
8. Did you experience difficulty in high school or college Icelandic classes?	.659		
9. What is your current attitude toward reading	.199	.589	
10. How much reading do you do for pleasure?	–.103	.978	–.106
11. How would you compare your current reading speed to that of others of the same age and education?	.425	.398	
12. How much reading do you do in conjunction with your work? (If retired or not working. how much did you read when you were working?)		.313	
13. How much difficulty did you have *learning to spell* in elementary school?	.814		
14. How would you compare your current spelling to that of others of the same age and education?	.671		
16. Do you ever have difficulty remembering people's names or names of places?			.816
17. Do you have difficulty remembering addresses. phone numbers. or dates?			.839
18. Do you have difficulty remembering complex verbal instructions?		.153	.484
19. Do you currently reverse the order of letters or numbers when you read or write?	.594		.229
20. How many books do you read for pleasure each year?		.911	–.122
21. How many magazines do you read for pleasure each month?		.318	
22. Do you read daily (Monday–Friday) newspapers?		.298	
23. Do you read a newspaper on Sundays?		.314	.134

Note. Extraction method: maximum likelihood. Rotation method: Oblimin with Kaiser normalization. Rotation converged in 5 iterations. Coefficients < .10 suppressed. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.

Table 6. Means and Standard Deviations of the ARHQ-Ice Total (Percentage Scores) and Factor Scores (Raw Scores) of Recruitment Groups.

	Familial (n = 1,448)		Nonfamilial (n = 739)
	Diagnosed (n = 458) (F81) *M* (*SD*)	Relatives (n = 990) *M* (*SD*)	Controls (n = 739) *M* (*SD*)
ARHQ-Ice	0.56 (0.16)	0.36 (0.18)	0.31 (0.15)
Dyslexic symptoms	29.55 (9.69)	17.55 (11.08)	13.99 (8.94)
Current reading	13.55 (5.81)	9.18 (5.16)	9.09 (4.74)
Memory	6.54 (3.14)	4.95 (3.15)	4.55 (2.80)

Note. Significant (p < .001) group effects were found for all scores. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.

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Table 7. ARHQ-Ice Raw Factor Scores.

	Dyslexics F81.0	Nondyslexics		
	M (*SD*)	*M* (*SD*)	*t*	*p*
Dyslexic symptoms	30.49 (9.09)	12.72 (7.82)	34.35	< .001
Current reading	13.83 (5.78)	8.90 (4.70)	15.44	< .001
Memory	6.60 (3.20)	4.40 (2.76)	12.08	< .001

Note. *t* test for equality of means and standard deviations for diagnosed F81.0 specific reading disorder (n = 419) and defined nondyslexics (n = 679), df = 1,096. ARHQ-Ice = 22-item version of the *Adult Reading History Questionnaire* (ARHQ) adapted for Iceland.

relatives, and population controls in the direction expected, the highest scores in the diagnosed group and the lowest in the population controls (Table 6) and greater differences in means between the groups defined for the validity study as dyslexics and nondyslexics (Table 7).

Discussion

Dyslexia is considered the most prevalent developmental disorder in Iceland as in most parts of the Western world (Marinosson et al., 1997; Vellutino et al., 2004). Although much improvement has been made in recent years in diagnosing dyslexia in Icelandic children of elementary school age, less is known about the presentation and prevalence of adult dyslexia in Iceland (Marinosson et al., 1997). A screening measure that can be used to predict dyslexia (as defined by diagnostic standards such as the ICD-10) would be of considerable value in research and practice in Iceland. In higher education settings it could promote better self-understanding for those screened and a direction toward future assessment needs or educational support in light of results. The aims of the present study were to test psychometric properties of such a measure, an Icelandic translation of the ARHQ by Lefly and Pennington (2000), and to assess its validity as a broad phenotype measure of adult dyslexia for a genetic study of dyslexia in Iceland.

Various psychometric tests in the large and diverse sample of adults found the Icelandic translation comparable to its U.S.-developed counterpart. Specifically, the considerable longitudinal stability observed (within-subjects correlation of .93 between responses on average 1.6 years apart) supports claims that adults can reliably recall and report on their childhood reading history and their experience of the fundamental symptoms of childhood dyslexia (Lefly & Pennington, 2000).

The validity of the 22-item ARHQ-Ice was tested in various ways. Comparing mean scores of the three recruitment groups, we found, as expected, adult participants who had as children or adolescents been diagnosed with any specific disorder of scholastic skills (F81) scoring significantly higher than relatives, and both familial groups (diagnosed and relatives) scoring significantly higher than population controls (Table 6). These results are indicative of a greater prevalence of undiagnosed dyslexia or more prominent symptoms along the now recognized spectrum of phonological and memory processes associated with dyslexia (Vellutino et al., 2004), among first- and second-degree adult relatives of F81-diagnosed individuals than in the general population control group. This is concordant with reports of the high heritability of dyslexia (Hawke et al., 2006) and the aforementioned studies in which high ARHQ scores of parents conferred increased risk of dyslexia among their children (Friedman et al., 2003; Pennington & Lefly, 2001).

Consistent with estimated prevalence of reading difficulties indicative of possible dyslexia among Icelanders (Marinosson et al., 1997), 9% of controls self-reported dyslexia (Table 1). On the other hand, of those who as children or adolescents had received a specific reading disorder diagnosis (F81.0), eight participants denied having dyslexia as adults (Table 1). These may represent adults who despite receiving a childhood diagnosis of dyslexia have reached a level of compensation so that they no longer consider themselves dyslexic. The shallow Icelandic orthography, where letters of the alphabet are in most cases uniquely mapped to specific speech sounds, may facilitate such compensation. Indeed, studies have shown that learning to read in languages with shallow orthographies is easier than in languages with deep orthographies and that despite a common neurocognitive deficit in dyslexia, its manifestation may be less severe in shallower orthographies (Paulesu et al., 2001).

When comparing ARHQ-Ices scores of the more specifically contrasted groups defined for the validity study, of adults who via a uniform neuropsychological evaluation received the main diagnosis of dyslexia (F81.0 specific reading disability) and general-population-recruited nondyslexics (their dyslexia status albeit ascertained in a different manner from the dyslexics), the significant differences in ARHQ-Ice scores became even more marked (see Table 2). As the dyslexic and nondyslexic groups also differed in terms of demographic composition, a discriminant function analysis was indicated, which revealed that ARHQ-Ice scores along with age when answering the surveys were the best predictors of a dyslexia diagnosis, gender and length of education contributing very little to the discrimination between dyslexic and nondyslexic status. We contend that the negative correlation (r = –.71) of age with the discriminant function has more to do with how differently aged the recruitment groups were (the diagnosed group significantly younger than both comparison groups, as shown in Tables 1 and 2) than an association of ARHQ-Ice scores with age, although this warrants further study. The fact that the ARHQ-Ice scores were strongly and positively associated (r = .68) with dyslexic status when

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adjusting for gender, education, and age when answering further supports the validity of the ARHQ-Ice.

To determine the applicability of the ARHQ-Ice as a screening tool for adult dyslexia, we used an ROC curve analysis and determined that classifying those with ARHQ-Ice scores greater than .43 as dyslexic resulted in the best balance between sensitivity and specificity, sensitivity represented by the proportion of true positives (F81.0 diagnosed) correctly identified with the ARHQ-Ice-defined cutoff (84.5%) and specificity represented by the proportion of true negatives (nondyslexic population controls) correctly identified by scoring below or at the ARHQ-Ice cutoff (83.3%; Figure 1). In comparison, Lefly and Pennington's (2000) test of the original ARHQ reported a cutoff of .40 (for the 23-item version) with sensitivity of 81.8% and specificity of 77.5% (Lefly & Pennington, 2000). For practical purposes, these cutoff scores are very similar, the slight difference attributable to our Icelandic measure lacking one item and the score range thus spanning 88 points instead of 92. Both language versions of the ARHQ therefore fulfill criteria of screening tests for developmental disorders, which reportedly should demonstrate at least 70% to 80% sensitivity and specificity (Glascoe, 2005).

A final validation test addressed the construct validity of the ARHQ-Ice scale, a factor analysis suggesting three factors that we describe as representing measures of dyslexic symptoms, current reading, and memory (Tables 5–7). The results suggested that further refinement is needed of the memory and current reading scales, which were considerably weaker than the robust dyslexic symptom scale. The memory scale contained only three items, and the current reading scale had too many weak factor loadings and did not adequately reflect recent societal changes in reading habits and reading materials. For example, newspapers and magazines are increasingly read online in highly web-penetrated societies such as Iceland (with web penetration of more than 90%; Iceland Statistics, 2010). Despite identified weaknesses of particularly the memory and current reading factors, all three factors demonstrated internal consistency, with Cronbach's alphas exceeding the normally accepted .80 limit (DeVellis, 2012). Furthermore, the significant differences observed among the three recruitment groups in the expected direction for all suggested subscales of the ARHQ-Ice (Tables 6 and 7) make them intriguing for further research as well as for clinical purposes.

Limitations

This study has several limitations. First, our samples are based on convenience sampling, selected from retrospectively available ARHQ scores collected within the context of recruitment for a genetic study of dyslexia. This speaks to the representativeness of our results, specifically in terms of the young age of our diagnosed group compared to the considerably older relatives and nondyslexic control group. The studies previously reviewed, however, indicate that reading difficulties persist over the life span, even in compensated adult dyslexics, and are reflected by the recall of dyslexic symptoms in childhood as measured by the ARHQ. Another limitation is that our nondyslexic group was not defined by the same formal diagnostic process as was the dyslexic group, which may affect the sensitivity and specificity analysis. However, the exclusion criteria used for the population control group were so strictly defined that it is highly unlikely that undiagnosed dyslexic adults (false negatives) were among our controls. Third, we had no socioeconomic data on our participants other than education status, and therefore we have limited generalizability to individuals of different socioeconomic backgrounds. However, the size of our data set and breadth in education levels seen within it among both dyslexics and nondyslexics suggest that generalizations can be made, at least to the Icelandic population. With the results obtained within the uniformly assessed and diagnosed clinical group and a comparison group of nondyslexic and neurocognitively unaffected adults from a general population sample, we consider the Icelandic ARHQ-Ice a valid and reliable screening measure of adult dyslexia.

Conclusion

In conclusion, this first psychometric test of the ARHQ-Ice finds it a valid and reliable screening measure of adult dyslexia that is feasible for use in both research and clinical practice in Iceland. Administration time is only 10 to 15 minutes.

In clinical practice or screening of students in academic institutions, a cutoff providing the best balance between sensitivity and specificity must be selected. With the .43 cutoff demonstrating a sensitivity of 84.5% and specificity of 83.7%, use of the ARHQ-Ice in large-scale screening efforts such as for epidemiological studies in Iceland is justified. Academic institutions may choose to provide assistance based on ARHQ-Ice results and/or refer the student to more detailed evaluation and diagnosis. Finally, for genetic studies, the ARHQ-Ice represents with acceptable sensitivity and specificity a broad phenotype of adult dyslexia in the absence of a formal diagnosis. For affected-only studies, higher cutoff scores than the suggested .43 may be warranted, thereby increasing specificity (although at the cost of losing a greater number of true dyslexics). Warranting further study are the identified ARHQ-Ice subscales as possible endophenotypes among adult dyslexics.

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