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Can self-report data on deficits in reading and spelling predict spelling disability as defined by psychometric tests?

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Abstract. Questionnaire data concerning spelling and reading self-assessment, habits, and school history were obtained for 79 adults (54 women and 25 men). The items were used to predict affectedness as defined on the basis of psychometric tests. For this purpose, two different discriminant analytical approaches (linear discriminant analysis and hierarchical classification with CART) were compared using a cross-validation design. 86.8–92.6% of the learning sample and 87.5–88% of the cross-validation sample were classified correctly. The CART model was preferred due to a balanced relation of sensitivity and specificity. Our results support the conclusion that self-report data are appropriate to substitute psychometric tests if these cannot be administered.

Key words: Spelling disorder, Reading ability, Self-assessment

Introduction

Reading and spelling disorder (also called dyslexia) is one of the most frequently diagnosed disorders in childhood. The prevalence rate varies between 5 and 10 percent depending on the chosen diagnostic criteria and sample ascertainment strategies (Shaywitz, Shaywitz, Fletcher & Escobar 1990). Longitudinal studies showed a high continuity of the disorder into adulthood, especially for spelling disorder (Michelsson, Byring & Björkgren 1985; Strehlow, Kluge, Möller & Haffner 1992).

As recommended by the different classification systems (DSM IV and ICD-10), the diagnosis is based on standardised tests of reading and spelling. For adults, there is no consensus with regard to the procedure that should be used for diagnosis. Self-report data regarding school history (Gillis & DeFries 1989) and self-assessment of actual reading and spelling ability (Decker, Vogler & DeFries 1989) as well as psychometric tests are used for diagnosis (Pennington, Gilger, Pauls, Smith, Smith & DeFries 1991). As an alternative to individual testing, administering a questionnaire is less time consuming and does not require individual contact to the examined individual. Therefore, this diagnostic procedure is often preferred for adult phenotype definition in

family genetic studies (Smith, Kimberling, Pennington & Lubs 1983; Gilger, Pennington & DeFries 1991; Pennington et al. 1991; Wolf & Melngailis 1994).

Unlike of the extensive use of self-report data for the diagnosis of reading and spelling disorder in adults, little research has been done concerning the validity of this source of information. Decker et al. (1989) compared parents of reading disabled probands with parents of non-reading disabled probands. Composite reading/spelling scores of parents who reported reading problems were significantly lower than of those parents who did not report such problems.

A more detailed questionnaire consisting of 13 items regarding actual and past reading and spelling ability and reading habits was developed by Finucci et al. (1984). These 13 items were summed up to a total score and then compared with test data. As expected by the authors, the poorer adult readers would significantly more often than the better readers give unfavorable responses to questions about school histories, habits, and attitudes.

Although these two studies showed that there is in general a high relation between self-report and psychometric testing, family studies often require a phenotype classification into affected and non-affected subjects. To which extent self-report data may substitute test data for this special purpose, has to our best knowledge not yet been examined. In addition to the over-all goodness of classification, information on the specificity and sensitivity are of great importance for the evaluation of a questionnaire.

Therefore, the main objective of the present study was to analyse self-report data on present and past difficulties in reading and spelling using discriminant analytic techniques.

Method

Subjects. Thirty mothers and 22 fathers (22 couples and 6 single mothers) were assessed within a family genetic study (Schulte-Körne, Deimel, Mueller, Gutenbrunner & Remschmidt 1996). These adults were ascertained through a spelling disabled child that came to our outpatient clinic at the Department of Child and Adolescent Psychiatry and Psychotherapy of the Marburg University (Germany) for the first time. The parents of all children who fulfilled the inclusionary criteria were asked to participate in the study. Thirty-eight children fulfilled the inclusionary criteria. Six probands and their parents refused to participate, 3 parents did not complete the questionnaire and were excluded from the study. The final sample consisted of 52 adults. Additionally, 18 adults (16 women and 2 men) from an independent sample whose children participated in a dyslexia remediation study were examined. The

remedial training was carried out mainly by the mothers of dyslexic children. Therefore, women were more interested to participate in our study. Furthermore, 9 students for retraining (8 women and 1 man) were included in this study. These students were recruited from school which was supported by the employment exchange. From the 16 students two were male and 14 were female. Seven students were excluded from the study because their first language was not German. Inclusionary criteria for all subjects were an IQ >85, no uncorrected auditory and visual acuity, no apparent neurological, emotional or behavioral disorder or unusual educational circumstances that could account for the poor spelling ability and to be a native monolingual speaker of German.

Measures. The questionnaire was handed out and completed before psychometric testing. The Culture Fair Intelligence Test (Weiss 1987) and a standardized German spelling test (Jäger & Jundt 1973) were administered to each subject. Affectedness was assumed if actual spelling achievement (percentile rank as measured by the spelling test) was at least 1 standard deviation below the expected spelling achievement based on IQ. Expected spelling achievement was computed using a regression model (spelling on IQ) with an assumed correlation of the two measures of 0.42 (Glogauer 1977). The regression equation was derived from a large normative German sample which was independent from our sample. The underlying regression equation is: spelling (T-norm) = 0.42 $\times$ (SD IQ/SD spelling) $\times$ (IQ-100) + residual. Additionally, each subject completed a questionnaire which is partially based on the questionnaire developed by Finucci et al. (1984) regarding spelling and reading abilities, habits, and school history (see Appendix).

Data analysis. Male and female individuals of the family sample had to be analyzed separately because of assumed assortative mating effects (Schulte-Körne et al. 1996), which would lead to dependent pairs of values. Adults of the two other samples (see above) were added to these groups according to their gender. This procedure led to a larger women's sample (n = 54) and a smaller men's sample (n = 25). We used the larger sample (women) to perform a discriminant analysis. Subsequently, this model was applied to the smaller sample (men) in order to cross-validate the model. It has to be mentioned that these samples are not statistically independent in the strict sense. Nevertheless, the samples are not deterministically dependent and thus a positive bias towards correct classification in the cross-validation sample cannot be presumed.

Two different techniques of discriminant analyses using all items from the questionnaire were applied to our data. First, we computed a linear discrimi-

nant model. Second, hierarchic classification method was performed as used in the CART programs by Breiman, Freidman, Olshen & Stone (1984).

For the linear model we first cut down on the number of predictors by using stepwise discriminant analysis as performed by the Statistical Analysis System Software (SAS, Version 6). In the first step, this procedure selects the variable with the highest predictive value and then calculates *p*-values which describe the additional predictive power for each of the remaining variables. The variable that provides the highest amount of additional information for the model is added to the list of predictors. This procedure is continued until none of the remaining variables adds significantly to the model as defined by the list of selected predictors. Subsequently, a discriminant function was computed using the selected predictors.

CART is an abbreviation for *Correlation and Regression Trees*, and uses binary decision trees. In the first step, the program looks for a split of the sample into two subgroups that are as different as possible on the criterion variable. For this purpose the list of predictor variables is screened to find the best predictor. Additionally, the program looks for the value of the best predictor variable at which this split should be made. In the next step, the two resulting subgroups are separately analyzed in the same way. Regarding the optimal number of splits to be taken, CART uses an internal cross-validation technique.

Results

For the linear discriminant analysis, the data of 54 female and 25 male probands could be used. For the stepwise discriminant analysis and the CART analysis, one woman had to be excluded because of partly missing questionnaire data. Table 1 presents sample description in terms of age, IQ, and spelling ability.

Table 1. Sample characteristics on age, IQ, and spelling ability

	Age	IQ	Spelling percentile
Women (n = 54)	36.3 ± 5.6	110.4 ± 12.2	51.0 ± 29.6
Men (n = 25)	39.0 ± 5.7	108.7 ± 10.7	37.4 ± 31.4
p-value (median test)	$p = 0.20$	$p = 0.41$	$p = 0.07$

All numbers are means plus or minus standard deviations or percentile as indicated above.

Median tests showed that there are no significant gender differences concerning these variables. However, the rate of affected subjects diagnosed by psychometric tests is significantly higher in men (12 out of 25) than in

women (12 out of 54). This is not surprising because a higher rate of spelling disability in males has often been reported (Allred 1990; Newman, Fields & Wright 1993).

Linear discriminant analyses

The data of the 54 women were used to calculate a discriminant function. We first performed a stepwise discriminant analysis (significance level for variable selection $p = 0.05$). Two variables (self-assessment of spelling ability, *Spell_sa*, and self-assessment of reading ability, *Read_sa*) were selected. Subsequently, a linear discriminant function using these two variables was computed: $-9.6 + 2.7 * \textit{Spell\_sa} + 3.3 * \textit{Read\_sa}$.

Both female and male probands were then separately classified according to this function. The results are presented in Tables 2 and 3.

Table 2. Classification results of the linear discriminant analysis (female probands)

Test	Questionnaire	
	Not affected	Affected
Not affected	42	0
Affected	4	8

Sensitivity: 66.6%, Specificity: 100%, Percentage of total correctly classified: 92.6%.

Table 3. Classification results of the linear discriminant analysis (male probands)

Test	Questionnaire	
	Not affected	Affected
Not affected	12	1
Affected	3	9

Sensitivity: 75%, Specificity: 92.3%, Percentage of total correctly classified: 87.5%.

The total rates of correctly classified probands were very good in both samples. This shows that the computed model is appropriate for the women's sample (from which it was derived) as well as for the men's sample. The sensitivity is somewhat poor in comparison to the specificity. We tried to improve this relation by using different priors in the analysis, but a better balance between sensitivity and specificity led to a remarkable impairment of the over-all rate of correctly classified probands.

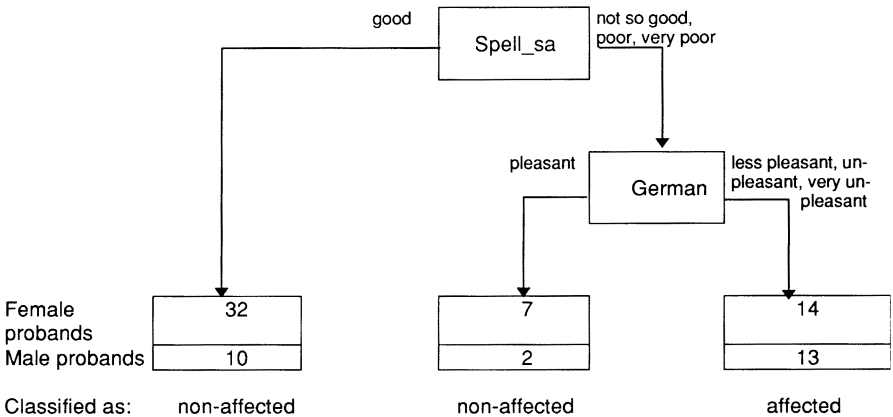

Figure 1. Decision tree and classification results for male and female probands.

Hierarchical classification using CART

Again, the sample of female probands was used for model calculation. CART analysis revealed that a model using 2 splits (on the variables self-assessment of spelling ability, *Spell_sa*, and perception of German lessons in school, *German*) would fit best with our data. Figure 1 shows the decision tree. Tables 4 and 5 present the classification results separated for male and female probands.

Table 4. Classification results of the CART analysis (female probands)

	Questionnaire	
Test	Not affected	Affected
Not affected	39	5
Affected	2	9

Sensitivity: 81.8%, Specificity: 88.1%, Percentage of total correctly classified: 86.8%.

Table 5. Classification results of the CART analysis (male probands)

	Questionnaire	
Test	Not affected	Affected
Not affected	11	2
Affected	1	11

Sensitivity: 91.7%, Specificity: 84.6%, Percentage of total correctly classified: 88%.

Similar to linear discriminant analysis, self-assessment of spelling ability proved to be the best predictor. All subjects but one who rated their spelling ability as good were classified as not affected. The rest (i.e., those who had rated their spelling ability as not so good, poor or very poor) was classified as affected. Since there still was a substantial number of misclassified subjects on this leaf of the tree, another split was taken then, using the perception of German lessons as split variable. Subjects who remembered their German lessons as pleasant were reclassified as being not affected. Further splits were not taken. Concerning the over-all rate of correct classification, the results are comparable to that of the linear discriminant analysis. In both samples (women and men), there are very high rates of correctly classified probands. However, the relation of sensitivity to specificity is better balanced.

Discussion

Aim of this study was to examine to what extent questionnaire data are suited to substitute psychometric tests for the diagnosis of spelling disability. Results show that there is a very high concordance between objective test measures and subjective self-report data. It was a somewhat surprising to find that single items like self-assessment of spelling ability are of very high predictive power. Results of the stepwise discriminant analysis (only 2 items were selected) show that the rest of the questionnaire provides only little additional information. Comparison of the two different discriminant analytical approaches (linear vs hierarchical) stresses the over-all significance of self-assessment of spelling. Both approaches provide only slightly different rates of correctly classified subjects. However, a close look at the classification tables reveals that the sensitivity is comparably poor in the linear model, for women as well as for men. This means that a considerable number of subjects (33% of the affected women and 25% of the affected men) are classified as not affected although they are affected in terms of psychometric tests. This will decrease the benefit of this model as a screening instrument for epidemiological and clinical research. On the opposite, the non-linear CART model is apparently better balanced: sensitivity and specificity are of almost equal size.

Both approaches use a second (but not the same) item to optimise classification results. It can be assumed that this difference reflects differences in the underlying mathematical techniques: stepwise discriminant analysis showed that the variable German does not contribute additional information if self-assessment of spelling ability has been partialled out, i.e. the discriminative power of the combination of these 2 variables is not significantly better than that of *Spell_sa* alone.

For the linear model self-assessment of reading was chosen as second predictor on spelling ability. This may be explained by the fact that reading and spelling are highly correlated (Torgesen 1989), and thus spelling disability and reading disability are often associated. This assumption could not be tested since there are no standardized German word decoding tests.

The relationship between self-reports and actual ability is not perfect and could be influenced by different factors. Gilger (1992) found that the accuracy of self-report data varied with subjects' gender, age and level of academic performance. Therefore, standardized tests should be preferred for the actual assessment of reading and spelling ability.

Although there are some methodological limitations regarding the representativness of the sample, our findings suggest the usefulness of self-report data for the diagnosis of spelling disability in adults, if psychometric data were not available.

Appendix: Questionnaire

Item-number	Items	Answers			
1	Difficulties in reading	No	Yes		
2	Difficulties in spelling	No	Yes		
3	Lessons in German language were	Pleasant	Less pleasant	Unpleasant	Very unpleasant
4	Tutoring in reading or spelling	Never	Seldom	Occasionally	Frequently and a long time
5	Number of grades repeated	None	One	Two or more	School drop out
6	Newspaper reading	Daily	Frequent	Irregular	Never
7	Magazines read per month	Five or more	Two to four	One	None
8	Books read per year	More than ten	Six to ten	One to Five	None
9	Spelling ability	Good	Not so good	Poor	Very poor
10	Attitude toward writing	I like to write	I do not like to write very much	I do not like to write	I hate writing
11	Reading ability	Well	Not so good	Poor	Very poor
12	Attitude toward reading	I like to read	I do not like to read very much	I do not like to read	I hate reading

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