Heidelberg Phoneme Discrimination Test (HLAD): Normative Data for Children of the Third Grade and Correlation with Spelling Ability

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Key Words

Heidelberg Phoneme Discrimination Test (HLAD) · Phoneme discrimination · Phoneme analysis · Writing capacity

Abstract

Objective: The Heidelberg Phoneme Discrimination Test (HLAD), developed and standardized in 1998, is widely used in the differential diagnosis of dyslexia. Normative data have only been available for children of the 2nd and 4th grades, while norms for the 3rd grade are still missing. **Patients and Methods:** We assessed three HLAD subtests [auditory phoneme discrimination, kinesthetic phoneme discrimination (repeating minimal pairs) and phoneme analysis] in 140 children of the 3rd grade from eight elementary schools. Writing capacity was tested via DRT3. **Results:** Comparing children of the 2nd, 3rd and 4th grades, we found a continuing increase in phoneme discrimination capacity with age. This increase was especially evident for the task of auditory comparison. For the 3rd grade, the correlation between HLAD and writing test (qualitative analysis) was 0.55, and 0.36 between HLAD and writing (quantitative analysis). The correlation with writing tasks was highest in the 2nd grade. **Conclusion:** The steady increase in phoneme discrimination capacity from the 2nd to 4th grade may indicate maturation and learning effects at least until the age of 10 years.

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Introduction

It is common knowledge in dyslexia research that there is not only one but several factors responsible for the difficulties concerning the acquisition of reading and writing skills in dyslexic children. These are social, academic, and familial factors as well as constitutional and cognitive aspects. One of the main risk factors relates to difficulties in speech and language development and speech perception [1–3]. Research into phonological processing and phoneme discrimination is getting more and more in the main focus of interest [4–9].

Impairment in phonological processing can be identified at different levels of processing: at the level of auditory analysis and discrimination, at the level of phonological temporary storage and/or at the level of transforming the phonological information into articulatory processing. Recent neuropsychological studies show a close relationship between phoneme discrimination ability and dyslexia [3]. It has also been shown that children with dyslexic parents are at higher risk for developing an impairment of phoneme discrimination [10]. Clinical experience revealed that many dyslexic children have pronounced difficulties in discrimination and correct articulation of similar sounds, in spite of normal hearing.

In view of the therapeutic options for these children a clear diagnosis of the impairment in phoneme discrimi-

nation and articulation is indispensable. Furthermore, it is important to distinguish this impairment from difficulties concerning the knowledge and use of rules in writing and reading. For this purpose standardized psychometric methods are used, such as the Heidelberg Phoneme Discrimination Test (HLAD) developed by Brunner et al. [11] and Dierks et al. [12]. This test is widely used in the diagnosis of auditory perception impairment and dyslexia in German-speaking countries. However, normative data are only available for the 2nd and the 4th grades.

In the HLAD, there are three factor scores that assess the child's auditory perception: phoneme discrimination is tested in part 1a as an auditory comparison, in part 1b as kinesthetic repetition. Part 2 tests metalinguistic skills on the basis of the ability to analyze consonant clusters, especially voiced and voiceless stop sounds at the beginning of a word. The HLAD is available with recording on a sound storage medium, and analysis of the data is computerized.

To test auditory comparison, children are presented 15 pairs of words and 9 pairs of syllables with a different mode of articulation but a similar position of articulation (e.g. /Seide-Seite/, /dra-tra/). Additionally, there are 8 pairs of words and one pair of syllables presented with a similar mode of articulation but a different position (e.g. /Kragen-tragen/). The children's task is to judge whether the pairs sound equal or not. The number of correct words and syllables is registered (HLAD; comparison). For analyzing kinesthetic repetition, the children have to repeat the pairs of words and syllables directly after the comparison task (equal or not equal). The number of correct repetitions is registered (HLAD; repetition). To evaluate phoneme discrimination ability, the children have to specify the first two consonants of 12 words beginning with voiced or voiceless stop sounds. The number of correctly analyzed consonants is registered (HLAD; analysis of word-initial phonemes).

The aim of the investigation was to establish norms for the 3rd grade. Here, dyslexia often appears for the first time when writing untrained dictations. Therefore, standardized evaluation is extremely important. Additionally, writing ability was also investigated. We did not investigate correlation with word reading, as we found in our longitudinal study [13] that language and speech processing variables differentially influence reading and spelling. There was a significant correlation only between speech sound perception and spelling, but not word reading.

Subjects and Methods

Subjects

Children of the 3rd grade from eight primary schools around Heidelberg, Germany were investigated. Participation in the study was only possible with the parents' permission. In total, 143 children, aged 7;7 to 10;6 (mean 9;1) years, were investigated. Because of hearing impairment due to middle ear ventilation 3 children were excluded from the study. We evaluated the results of 70 boys and 70 girls; 39 children grew up in a multilingual environment.

Methods

Children of each school were examined individually at the TNE-Heidelberg University Clinic (Phoniatrie und Pädaudiologie). Otoscopy and audiometric diagnostics were made, and phoneme discrimination was examined with the HLAD test, which was part of an extensive test battery. Each assessment lasted 3 h, with breaks in between. One month later, the writing ability of the children was examined in a group session using the German Orthography Test (DRT3) [14] during lessons.

Statistical analysis was done with the computer program SPSS 11.5.1 for Windows.

Results

For children of the 3rd grade, the mean of the raw score was 21 of 25 items for auditory phoneme discrimination, 17.3 of 25 items for kinesthetic phoneme discrimination, and 9.6 of 12 items for analysis of initial phonemes (table 1). Comparing the means of the 3rd grade to the means of the 2nd and 4th grades for auditory phoneme discrimination, there is a continuous increase from the 2nd up to the 4th grade for correctly analyzed items. For kinesthetic phoneme discrimination and the analysis of initial phonemes, the results show an increase from the 2nd to the 3rd grade but not from the 3rd to the 4th grade (table 2).

For the determination of normative values, percent ranges were computed for the raw scores of the HLAD, respectively. As pointed out, averages ranged between 15 and 85%. Raw scores according to the average range of the percent ranges, respectively, can be seen in table 3. For children of the 3rd grade, the average distribution of raw scores (RW) was RW = 18–24 for auditory phoneme discrimination (2nd grade: RW = 17–22; 4th grade: RW = 20–24), for kinesthetic phoneme discrimination RW = 12–22 (2nd grade: RW = 8–17, 4th grade: RW = 14–21), and for analysis of initial phonemes RW = 7–11 (2nd grade: RW = 4–10, 4th grade: RW = 7–11).

Correlation coefficients between the total score and the subtest scores of the HLAD and the DRT3 total score

Table 1. Distribution of raw scores

	HLAD				DRT3 total
	total	auditory comparison	kinesthetic repetition	analysis of word-initial phonemes	
Mean	47.6	21	17.3	9.6	19.7
SD	8.9	3.0	4.7	6.2	10.1

Table 2. Comparison (2nd, 3rd, 4th grades) of the means of correctly analyzed items (data for 2nd and 4th grades from Dierks et al. [12])

	2nd grade	3rd grade ¹	4th grade
Auditory comparison (total 25 items)	19.4	21	22
Kinesthetic repetition (total 25 items)	12.2	17.3	17.3
Analysis of word-initial phonemes (total 12 items)	6.7	9.6	9.3
HLAD total	38.3	47.6	48.6
¹ See table 1.			

Table 3. Distribution of the percent ranges (PR) of the HLAD raw scores: comparison of the 2nd, 3rd, and 4th grades

Raw scores	Auditory comparison, PR			Kinesthetic repetition, PR			Analysis of word-initial phonemes, PR		
	2nd grade	3rd grade	4th grade	2nd grade	3rd grade	4th grade	2nd grade	3rd grade	4th grade
0							2		
1				0			5		
2				1			8		
3				3			11		
4				6		1	15	1	
5				8			23	2	3
6				11	1		37	8	9
7				14	2		55	18	17
8				20	3	3	68	29	28
9				28	4	5	78	40	41
10				33	7	7	85	48	57
11	0			39	12		92	62	74
12	1			46	16	10	99	87	91
13				55	20	13			
14	3	1		64	25	18			
15	7	5		72	30	26			
16	14	10	1	78	36	33			
17	23	13	3	83	44	41			
18	31	18	8	87	51	52			
19	42	26	14	91	59	62			
20	55	34	21	96	67	70			
21	68	45	31	99	75	81			
22	80	56	43		83	90			
23	88	68	59		91	95			
24	95	81	76		96	99			
25	99	95	92		99				

Figures in italics are PR normal range.

and the DRT3 score of perception errors, respectively, are shown in table 4. All correlations but one are significant at the 0.01 level. Correlation coefficients >0.50 can be seen in correlations of the HLAD with spelling errors of

the category ‘perception error’ (table 4). Comparing the correlations between HLAD and the DRT in the different grades (2nd, 3rd, 4th), it becomes apparent that the highest correlations are for the 2nd grade (table 5).

Table 4. Correlations of HLAD and DRT3

	DRT3 total (word error)	DRT subscore 'perception spelling error'
HLAD auditory comparison	0.29*	0.51*
HLAD kinesthetic repetition	0.41*	0.52*
HLAD analysis of word-initial phonemes	0.27*	0.42*
HLAD total	0.36*	0.55*

* p = 0.05.

Table 5. Correlations of HLAD and writing ability in the 2nd, 3rd, and 4th grades (data for 2nd and 4th grades from Dierks et al. [12])

	Writing ability		
	2nd grade	3rd grade	4th grade
HLAD auditory comparison	0.44***	0.29**	0.21**
HLAD kinesthetic repetition	0.47***	0.41**	0.31***
HLAD analysis of word-initial phonemes	0.49***	0.27**	0.19*
HLAD total	0.55***	0.36**	0.31***

* p = 0.05; ** p = 0.01; *** p < 0.01.

Discussion

Comparing the raw scores of the HLAD for the 2nd, 3rd, and 4th grades and comparing the distribution of normative values, there is a continual increase in auditory phoneme discrimination with higher grades and with age. It seems that the ability to accomplish auditory discrimination between similar phonemes is increasing continually. Most of the consonants that had to be discriminated differed in the voiced/voiceless dimension. Psychoacoustically, the consonants differed in terms of formant transients and time analyses taking place in milliseconds [3]. Therefore, one has to assume that in normally developing children there are maturation and learning effects for auditory phoneme discrimination at least until the age of 10. However, as the size of the sample is rather small, we interpret this data as preliminary. Further studies should confirm these results.

Different results appeared for kinesthetic phoneme discrimination and the analysis of word-initial phonemes. A clear increase was found from the 2nd to the 3rd grade, but not from the 3rd to the 4th grade. Here, there was only minimal or no increase in the ability to analyze word-initial phonemes. On closer inspection, concerning auditory phoneme discrimination, one can see additionally that the spectrum of the norms is quite wide for the 2nd and 3rd grades, getting smaller only at the 4th grade. This means that the spectrum of ability for auditory phoneme discrimination is spread widely in the children of the 2nd and 3rd grades, while children of the 4th grade seem to be more on the same level concerning auditory phoneme discrimination.

Results for the analysis of word-initial phonemes showed that children of the 2nd grade are already able to achieve the same maximum values as children of the 4th grade. In total, it seems that the ability to analyze clusters of consonants at the beginning of a word is not yet fully developed in the 2nd grade, and normally completed at the end of the 3rd grade. Windsor [15] found similar results: it is important to analyze letter per letter at the beginning of the acquisition of writing skills. Later, however, analysis of connected word units such as syllables and morphemes gains influence.

Concerning the relationship between the ability of phoneme discrimination and spelling, the highest values were found for the correlation with the category 'perception errors' in the Diagnostic Writing Test (DRT) (table 4). It seems that problems of the auditory perception of voiced and voiceless consonants have an influence on errors of the phoneme-grapheme classification of these consonants. Unfortunately, corresponding data for the 2nd and 4th grades were not available.

Moderate correlations were found in the qualitative analysis of writing tests (category of perception errors) for the 3rd grade. Correlations of a similar order were shown by Schulte-Körne [3] between active discrimination of /da-ga/ and the writing ability of children of the 2nd grade. Table 5 shows that the correlation coefficients for the HLAD and the writing tests decrease the higher the grade or age, respectively. The highest correlation coefficients were shown in the 2nd grade. Accordingly, Möhring et al. [16] specified the HLAD as a significant predictor concerning the spelling ability of children of the 2nd grade. Graf [17] and Walter [18] showed that phonological processing and auditory phoneme discrimination ability are a meaningful factor especially in the 2nd grade. It is of significant impact at the beginning of learning the written language because accurate phoneme-

grapheme correspondence is most important at this age. In the higher grades other cognitive abilities seem to get more important for correct writing, like knowledge of rules and learning strategies. It is not yet clear whether this is also true for dyslexic children, or whether the influence of inadequate phoneme discrimination continues to be visible in these children to the higher grades. Schulte-Körne [3] reported a significant difference in phoneme

discrimination of /d-b/ between dyslexic children and normally developing children of the 5th and 6th grades. Our own clinical experience also suggests that dyslexic children show more errors concerning inadequate auditory perception up to higher school grades. On the basis of this study, however, we think that the test is best suited as a diagnostic tool for dyslexia in the lower grades of primary school.

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