Extended abstract

Phonological Processing in German Poor Readers: a Pilot Study Evaluating a Computer-Based Training Program


Background: Deficits in phonological processing, i.e., phoneme perception, phonological awareness, verbal short-term memory, and rapid access to long-term representations of phonological word forms, constitute the core deficit of developmental dyslexia. Accordingly, improving phonological processing skills may ameliorate reading and spelling abilities in dyslexic children. Training studies in this field focused on phoneme perception and phonological awareness. Concerning phoneme perception, studies consistently revealed training-induced performance enhancements, but the extent of transfer to reading and spelling abilities is still unclear. Concerning phonological awareness, training also evokes reliable improvements, which reliably transfer to reading and spelling abilities when the training is combined with systematic phonics instruction, i.e., instruction on grapheme-phoneme correspondences.

A number of studies in which positive transfer effects were found used computer programs. These provide several advantages over conventional programs. By applying adaptive learning algorithms, they ensure schedules optimized for each individual child and provide excessive practice which improves fluency and automaticity in basic skills. Furthermore, parents or other family members can supervise a computer-based training; no professionals are required. This allows an intensive training consisting of daily sessions of 20–30 minutes over a period of several weeks, a schedule that has proven successful in fostering phonological skills in dyslexic children.

Taken together, a computer-based program that combines training of phoneme perception and phonological awareness with an instruction in grapheme-phoneme-mappings seems a promising approach for remediation in children with dyslexia. In the present work we present such a program which we developed for German dyslexic children. Due to the special relevance of vowel length perception for German orthography, a set of vowel length tasks was designed in addition to tasks focussing on consonants.

Aims: The program aims to foster phoneme perception, phonological awareness and grapheme-phoneme-mappings in sets of consonant and vowel length tasks. The phonological tasks implemented into the program are adaptations of tasks which have proven successful in international training studies. Tasks that were originally designed for the phonology of other languages (e.g. English or French) were adjusted to the specifics of German phonology. In addition, tasks that were originally used in the context of face-to-face-instruction had to be transformed to a computer-based training format. The current study aimed at testing whether these adaptations are suitable. A sample of poor and normal reading primary school children completed a pilot version of the computer program. If the implemented tasks really tap into poor readers' phonological deficits, significant performance differences in favor of the normal readers should be found. A further aim of the study was to collect data from a large sample of children with normal reading abilities, in order to implement performance criteria for each task into an adaptive design of the follow-up version of the training program. Methods: Participants: Third- and fourth graders with normal and poor reading abilities were recruited from a primary school in Leipzig, Germany. In this school, children with poor reading and spelling abilities are instructed in special dyslexia classes for two years, starting at grade 3. In the dyslexia classes, children follow the normal Grade 3 curriculum, which is spread over a period of 2 years in order to provide extra training in basic reading and writing skills.

To qualify as poor readers, children had to be enrolled in a dyslexia class, and reading performance had to be more than one standard deviation below average in a standardized German reading test. To qualify as
typical readers, children had to be enrolled in a regular class and had to achieve a reading score exceeding two-third of a standard deviation below average age in the same test. The resulting sample consisted of 35 poor readers (17 male, mean age 9;4) with mean reading score two standard deviations below average, and 75 normal readers (30 male, mean age 9;4) with mean reading scores half a standard deviation above average.

Training program: The pilot version of the training program consisted of 17 tasks with 20 to 30 trials each. The phoneme perception tasks required discrimination and identification of stop consonants and vowel lengths in words and pseudowords (CV, VCV, CCV, VCCV for consonant tasks, CVC for vowel length tasks). Stop consonant perception was trained with a further task requiring recognition of a target pseudoword within a sequence consisting of the target and two phonological similar distractors. The phonological awareness settings comprised odd-one-out-tasks requiring to decide which one out of three words or pseudowords differed from the other ones with respect to the initial or final consonant or with respect to the vowel length, and tasks involving phoneme segmentation (i.e., counting of sounds in words, segmenting words into the constituent sounds). The consonant identification and phoneme segmentation tasks incorporated grapheme-phoneme-mappings: Once the correct phonemes were selected, the respective graphemes had to be attached to them. Graphemes and phonemes were represented on the user interface through different building blocks, with the phoneme blocks made distinguishable by pictures of common objects. The initial sound of the object's verbal label represents the phoneme (e.g., fish for /f/).

Procedure: Children worked individually on the tasks in small groups of up to 10 children, supervised by two research assistants. A task was finished when all trials were solved correctly. Whenever a child produced an error or exceeded the time limit, the respective trial was repeated immediately. Thus, individual children differed in the number of trials necessary to complete each task. In total, children spend 3 to 6 school lessons to complete all 17 tasks.

Results: For each child, the proportion of additional trials (errors and timeouts) needed to complete a task was computed for all 17 tasks. For example, a child who produced four errors and one timeout in a task consisting of 20 trials would achieve a score of (4+1)/20 = 0.25 for this particular task. Group differences were analyzed by means of t-tests and Analyses of Variance (ANOVA). In all of the 17 tasks, poor readers showed lower performance than normal readers. All group differences proved medium to large effect sizes (Cohen's d, proposed by Cohen, 1988; medium: \(d \geq 0.50\); large: \(d > 0.80\)). Concerning consonant and vowel length perception, the effect sizes of the group differences ranged from 1.3 to 1.5 and 0.73 to 0.83, respectively. Further analyses including phonological structure of the pseudowords as within-subject variable revealed that poor readers' deficits in consonant perception are especially pronounced when target consonants are embedded in consonant clusters.

Concerning phonological awareness, effect sizes for the two phoneme segmentation tasks and the odd-one-out-task requiring comparison of the initial and final sounds in three pseudowords were 0.89, 1.29, and 2.19, respectively. The poor readers' marked difficulties with the odd-one-out-task were not due to the short-term memory load involved in this task. This was shown by means of an ANOVA including Task as within-subject-factor (odd-one-task vs. consonant perception task requiring recognition of a target in a sequence of three pseudowords). Despite comparable short-term memory load, the group differences were much stronger for the odd-one-out task, as confirmed by a significant Group x Task – interaction.

Discussion: The poor readers were outperformed by the normal readers in all 17 tasks of the pilot version of the training program, with group differences of medium to large effect sizes. These results confirm that the implemented tasks tap into poor readers' phonological difficulties. More detailed comparisons of specific tasks revealed that the severity of poor readers' deficits in consonant perception is dependent on syllable structure, with consonants embedded into clusters being much harder to perceive than single consonants. Prior studies have documented that dyslexic children exhibit special difficulties in reading and spelling of consonant clusters. The current findings indicate that deficits in the perception of consonant clusters may contribute to these difficulties.
Concerning phonological awareness, poor readers exhibited particularly severe difficulties in a task requiring comparison of the initial or final sounds of three pseudowords (odd-one-out). These difficulties cannot purely be attributed to short term memory deficits, as the group differences in favor of the normal readers were much smaller in a consonant perception task involving a comparable short-term memory load. These results indicate that poor readers have special difficulties in tasks requiring both storage and processing of phonological information.

To conclude, the introduced tasks that were designed for the phonological training program seem promising in that they differentiate between normal and poor readers. Therefore, all of the tasks designed so far will be retained in the follow-up version of the program. It has to be kept in mind, however, that from the current results nothing can be inferred about the efficacy of the training in ameliorating reading and spelling abilities in dyslexic children. The evaluation of the training's efficacy is subject of a further study, which is currently conducted with a sample of 64 primary school children with dyslexia.

**Keywords:** developmental dyslexia; intervention; German; phonological training; phoneme perception; phonological awareness; grapheme-phoneme-mapping