Author(s): Heikkilä, Riikka; Aro, Mikko; Närhi, Vesa; Westerholm, Jari; Ahonen, Timo

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Year: 2013

Version:

Please cite the original version:

Heikkilä, R., Aro, M., Närhi, V., Westerholm, J., & Ahonen, T. (2013). Does training in syllable recognition improve reading speed? A computer-based trial with poor readers from second and third grade.. Scientific Studies of Reading, 17(6), 398-414. https://doi.org/10.1080/10888438.2012.753452

Running head: Repeated Syllable Recognition

Does training in syllable recognition improve reading speed? A computer-based trial with poor readers from second and third grade

Heikkilä, R.(1, 2), Aro, M.(1), Närhi, V.(3), Westerholm, J. (2), & Ahonen, T.(1, 2)

1) University of Jyväskylä

2) Niilo Mäki Institute

3) The Finnish Association on Intellectual and Developmental Disabilities (FAIDD)

Acknowledgements: This study has been funded by A Finnish Slot Machine Association (RAY, The Preventing and Rehabilitation of Reading Disabilities project, 2006 - 2009) and by Ministry of Education (LukiMat project, 2007 - 2009). We are grateful to people working in LukiMat project for their support in the data collection and computerizing the training method. We also want to acknowledge Asko Tolvanen for assistance with the statistics and Heikki Lyytinen and Kenneth Eklund for their help in revising the content of the manuscript. We thank Kalle Rademacker, Jennifer Nelson, and Ulla Richardson for their assistance with revising the language.

Abstract

Repeated reading of infrequent syllables has been shown to increase reading speed at the word level in a transparent orthography. This study confirms these results with a computer-based training method and extends them by comparing the training effects of short syllables and long frequent and infrequent syllables, controlling for rapid automatized naming. Our results, based on a sample of 150 poor readers of Finnish, showed clear gains in reading speed regarding all trained syllables, but a transfer effect to the word level was evident only in the case of long infrequent syllables. Rapid automatized naming was associated with initial reading speed, but not with the training effect.

Keywords: reading disability, reading fluency, intervention, training study, rapid automatized naming

Reading fluency, usually defined as accurate reading with adequate speed and prosody (Kuhn & Stahl, 2003; NICHD, 2000), is a prerequisite and a correlate to reading comprehension (Klauda & Guthrie, 2008; Therrien, 2004) as the automatization of reading processes releases cognitive resources for higher level processing (LaBerge & Samuels, 1974; Perfetti, 1985). This automatization process is gradual and developmental, rather than being an on/off skill, and is a result of lexical and sublexical processes that lead to well-specified representations of orthographic items (Kame’enui & Simmons, 2001; Share, 2005). However, children with reading disabilities seem to have difficulties in attaining these skills. Fluency problems have proven to be very persistent (de Jong & van der Leij, 2003; Landerl & Wimmer, 2008) and rather resistant to intervention, at least in regard to attaining a normal reading level (Meyer & Felton, 1999; Thaler, Ebner, Wimmer, & Landerl, 2004). However, even limited progress in reading speed can have an effect on both reading accuracy and comprehension (Breznitz, 2006). Therefore, in this study, we focus on the speed component of reading fluency and aim to intervene in dysfluent reading in a highly transparent language, Finnish.

A growing body of research is now exposing slight differences in reading development in opaque and transparent languages. In opaque languages like English, the development of accurate reading takes remarkably more time than in more regular orthographies (Seymour, Aro, & Erskine, 2003). Therefore, in transparent orthographies (like German, Dutch, Spanish, Italian, and Finnish), reading problems manifest as slow and laborious reading rather than inaccurate reading (Escribano, 2007; Holopainen, Ahonen, & Lyytinen, 2001; Wimmer, 1993; Yap & van der Leij, 1993; Zoccolotti et al., 1999). In regular orthographies with almost perfect transparency between letters and phonemes in both directions (e.g. Finnish, Italian), it is possible for readers to attend to very small units and to adhere to a serial letter-by-letter reading strategy (Frost, Katz,

& Bentin, 1987; Pagliuca & Monaghan, 2010; Ziegler & Goswami, 2005). It seems, however, that using sublexical units larger than letters would benefit the reader in transparent orthographies even when it is possible to construct the word from single letters (Pagliuca & Monaghan, 2010; Paulesu, 2006). Therefore, intervention methods that help the reader to disentangle himself from a reading strategy based on an assembly of small units are needed to support reading fluency. Gains in fluency would promote reading comprehension (Breznitz, 2006), but also reinforce motivation towards reading, which has been shown to increase time spent reading (Leinonen et al., 2001).

The recognition units most commonly addressed in fluency intervention have been words, but training in sublexical units like consonant clusters (Hintikka, Landerl, Aro, & Lyytinen, 2008, Marinus, de Jong, & van der Leij, 2012), syllables (Huemer, Aro, Landerl, & Lyytinen, 2010; Tressoldi, Vio, & Iozzino, 2007), and morphemes (Burani, Marcolini, De Luca, & Zoccolotti, 2008) has also been shown to promote reading skill in transparent languages. Which units are most beneficial may vary, depending on the features of the language (Duncan, Colé, Seymour, & Magnan, 2006). The reason why training with whole *words* is unlikely to be effective in Finnish is inherent to the agglutinative nature of Finnish inflectional morphology, which results in numerous word forms (based on case and number (Karlsson, 2008)) and increases in word length. As most of the effects of training based on repetition of learned material are known to be item-specific (Berends & Reitsma, 2006; Lemoine, Levy, & Hutchinson, 1993; Marinus et al., 2012; Thaler et al., 2004), training with words in Finnish would require practicing all common word forms, which is not possible. In Finnish, many of the previously mentioned sublexical units are also problematic as targets of practice. First, *consonant clusters* are uncommon and are rarely found in word-initial (and never in word-final) position. Second, Finnish morphology is very complex and the same *morpheme* can be marked in several ways, depending on the context (for a more detailed description of the Finnish language, see Aro, 2006; Leinonen et al., 2001; Niemi, Laine, & Tuominen, 1994). Therefore, as Huemer and colleagues (2010) have summarized, the *syllable* is potentially a more useful perceptual unit in Finnish for various reasons, most obviously because of the polysyllabic nature and the clear syllable structure of the language. Indeed, syllables seem to be effective units in promoting reading speed in languages with a clear syllable structure (Finnish: Huemer et al., 2010; Italian: Tressoldi et al., 2007; and Dutch: Wentink, van Bon, & Schreuder, 1997).

The role of syllables in reading development (and, accordingly, in training) is also supported by some theoretical models. With its specific focus on reading of multisyllabic items, the Multiple-Trace Memory (MTM) model (Ans, Carbonnel, & Valdois, 1998) postulates that polysyllabic low-frequency words and nonwords that cannot be recognized as a whole unit are analyzed and broken down into syllables. It is also hypothesized that immediately after graphophonemic processing has become automatic, children turn to graphosyllabic processing: they begin to extract units that are larger than phonemes (Duncan et al., 2006; Ecalle & Magnan, 2007). This is in line with the idea of the self-teaching mechanism in decoding (Share, 1995). It enables the reader to learn item-specific associations between print and sound during independent reading practice. These learned associations are thought to bypass serial sublexical processing and enhance the use of orthographical representations in reading.

Turning to intervention methods, the most common used for fluency training is repeated reading, a method based on repetition of reading material, usually words or texts (for reviews, see Chard, Vaughn, & Tyler, 2002; Kuhn & Stahl, 2003; Therrien, 2004). Repeated reading can be used in an assisted tutor-learner setting, as an independent practice according to traditional methods, or in computer-assisted methods (Huemer, 2009). Since an increase in fluency seems to require multiple repetitions (Chard et al., 2002; Lemoine et al., 1993), repeated reading methods implemented in computer environments offer an appealing and cost-effective alternative to one-on-one tutoring. Computers are available in most cases, providing a standard presentation of tasks, sufficient repetitions with immediate feedback, and possibly more motivating training methods than traditional repeated reading. In addition, computer-assisted methods have proven to be beneficial for fluency training (Huemer, 2009; Huemer, Landerl, Aro, & Lyytinen, 2008; Irausquin, Drent, & Verhoeven, 2005) and for producing lasting effects in reading by means of syllable-based training (Ecalle, Magnan, & Calmus, 2009). To overcome the problem of monitoring reading, this study uses a computer-assisted method of repeated recognition of targeted units (syllables).

The first study that combined direct syllable training with repeated reading practice (Huemer et al., 2010) showed that gains in syllable reading speed were transferred to pseudowords containing practiced syllables. That study explored the effect of syllable training with *infrequent* syllables, in which the training effect was expected to be greater, due to less exposure to the material prior to training. Our study aimed to determine if those results could also be replicated with *frequent* syllables, which are more essential in everyday reading (in the sense that more frequent syllables potentially have a greater direct effect on general reading, as they comprise a larger portion of the text than the same amount of infrequent syllables). In our study, we included syllables with no semantic meaning that vary in frequency and length.

It is known that frequent words are read more accurately and faster than infrequent words (Berends & Reitsma, 2006). However, the results regarding the effects of *syllable frequency* are slightly more heterogeneous, depending on the reading task (lexical decision or naming), on the item used in reading (word or nonword), or on the language under investigation. Especially it depends on the consistency of the stress assignment in the language (e.g. Conrad, Stenneken, & Jacobs, 2006). To our knowledge, the effect of syllable frequency on reading single syllables has not been studied before. In this study, we compared effects of training related to *frequent and infrequent long* (four-letter) *syllables*. Because the lexicality effect is not present in syllable reading, we expected the initial reading speed of frequent syllables to be faster than that of infrequent syllables, due to greater prior exposure but also based on the results yielded by pseudoword reading, in which a facilitating effect of syllable frequency has been found (Carreiras & Perea, 2004). At the same time, however, due to less prior exposure to infrequent syllables, we expected greater gains in reading speed of infrequent than frequent syllables after repeated reading. Since the *length effect* seems to be strong in poor readers and appears to decrease with practice (Maloney, Risko, O'Malley, & Besner, 2009), we assumed that the training effect should be relatively greater for longer syllables, indicating a shift from letter-by-letter processing to recognition of a syllable as a unit. As several studies have shown the effects of training with single items to be item-specific (e.g. Berends & Reitsma, 2006; Thaler et al., 2004), we expected generalization only with materials containing practiced syllables, particularly pseudowords containing practiced syllables, following the results by Huemer et al. (2010).

Finally, a number of factors other than method and content presumably affect the effectiveness of training. For instance, various studies have indicated that children with naming speed deficits show less of a response to reading instruction (Berninger et al., 2002; Stage, Abbott, Jenkins, & Berninger, 2003) and benefit less from repeated reading than children without naming speed deficits (Bowers, 1993; Levy, Bourassa, & Horn, 1999). However, the response to fluency training has not always been merely affected by slow naming speed (Levy, Abello, & Lysynchuk, 1997), particularly after the initial reading level has been controlled for (Berends & Reitsma, 2006). As we acknowledge the strong connection between rapid automatized naming (RAN) and reading fluency (for the most recent reviews, see Kirby, Georgiou, Martinussen, & Parrila, 2010; Norton & Wolf, 2012), we expected that RAN would be associated with initial reading speed, if not with the effects of training.

In summary, in this study we explored if syllable reading speed can be improved through repetitive recognition tasks. Further, we examined if the improvement is dependent on the type of practiced items (length or frequency of the syllable) and also if the gains acquired in syllable training are item-specific but still transferrable to the word-level. Finally, we analyzed if individual variation in RAN and initial reading speed interact with the training effect.

Methods

Participants

The participants were poor readers attending second and third grade, selected from 81 classrooms across Finland. An e-mail was sent to second and third grade special and general education teachers registered in a nationwide Internet service that provides information on learning difficulties (www.lukimat.fi). The teachers were instructed to nominate pupils who are receiving part-time special education due to reading problems. Parents were informed about the purpose and implementation of the study. All volunteering children with parental permission *(n* = 265) were allowed to participate in the training under the guidance of their teachers (*n* = 93). The children were randomly divided into training and control groups of equal sizes. After the training period and a post-training test, children with incomplete assessment or training data (*n* = 72), multiple deficits in learning or cognition (i.e. a status of full-time special education or reported neurological problems; *n* = 33), or whose mother tongue was not Finnish (*n* = 1) were excluded. To further ensure the reliability of the reading speed assessment, children with very low reading accuracy (2 *SD* below the mean of the sample, *n* = 9) were excluded. All included participants followed the normal curriculum.

The final sample of participants consisted of 150 children: 96 second-graders and 54 third-graders. The mean age was 9 years, 2 months (*SD* = 6 months) and 59% of the participants were boys. According to the teachers' reports, reading speed was the main problem for 65% of the participants, and 70% had no other learning problems than reading. To provide additional information on the reading level of children included in the study, we compared the reading performance of our sample with representative data of poor and typical readers in Finnish (Jyväskylä Longitudinal Study of Dyslexia, JLD, reported in Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010). The mean of reading speed was measured on the basis of text reading. The word reading speed of this sample was 1.8 *SD* below the mean of the typical readers in JLD data (for both second and third graders). This was highly comparable to the children with dyslexia in the JLD sample, whose word reading speed was 1.9 *SD* below the normative mean for 2^{nd} graders and 1.7 *SD* for 3^{rd} graders. The range for reading speed was also comparable to the JLD dyslexic sample. The fastest readers in this sample were close to the average of typical readers in the JLD sample.

During the training sessions, one group of children practiced a blend of two-letter syllables (Group-2L; *n* = 48), another group practiced four-letter frequent syllables (Group-4LF; *n* = 30), and yet another group rehearsed four-letter infrequent syllables (Group-4LI; *n* = 37), all selected for the purposes of this study according to their frequency and structure. The two-letter syllables were matched with the four-letter frequent syllables according to their frequency, and the four-letter frequent syllables with the four-letter infrequent syllables according to their structure (see table 3). The control group (*n* = 35) practiced math tasks that did not require reading skills. Due to some attrition between the pre- and the post-training assessments, the resulting group sizes were uneven. However, the groups did not differ in age, naming speed, reading speed, or gender distribution (see Table 1 and Results: Pre-Training Measurements), nor in reading errors (Table 2).

Tables 1 and 2 about here

Our study was conducted in schools over a four-week period. The study consisted of a pre-training assessment, the training itself, and a post-training assessment conducted by teachers as instructed by the authors. The pre- and post-training tasks, together with detailed instructions for performing the assessment and using the training program, were sent to the teachers prior to the study. This package also included forms to aid teachers and parents in providing background information on the children, as well as a letter with information for the parents. Teachers were also given a contact number to call for support and guidance on the procedures.

Assessment Procedure.

All of the assessments were carried out individually by teachers. Teachers were instructed to present the tasks according to printed instructions and not to give any feedback to students during assessment; all tasks were printed on paper. The students were instructed to read the material aloud as quickly and accurately as possible. The completion time for the text or list was used as an outcome score. The assessment sessions were recorded (via a recording application integrated into the computerized training program) and stored online on a secure server. An advanced psychology student coded the completion times of the tasks and the percentage of accurately read items (syllables in the syllable lists and words in pseudoword lists and the text), and then checked the correctness of the assessment procedure from the recordings. Training began immediately after the pre-training assessment. The post-training assessment was conducted within two weeks of the final training session. The presentation order of the tasks was fixed: three syllable lists, three pseudoword lists, a text reading task and finally a rapid naming task. To avoid a strong priming effect, two list reading tasks were always situated between the syllable list and the pseudoword list containing the same syllables (e.g. two other syllable lists between the 2L-syllable list and the list of pseudowords containing the 2L-syllables).

Syllables. Separate lists for each type (3) of trained syllables were constructed, each consisting of all (30) trained syllables. The lists were presented in the same order for all participants. The order of the syllables within a list differed in the pre- and post-training tests.

Pseudowords. Three lists of two-syllable pseudowords were constructed, each containing all the practiced syllables of particular type and presented in a similar manner as the syllable lists. Because of orthographic legality restrictions, 22 of the practiced syllables were initial and 8 were final syllables of pseudowords.

Control task: Text reading. Two informational 120-word texts on animals (see Huemer et al., 2010) were read aloud, one as part of the pre-training and the other as part of the post-training test. Altogether, the practiced syllables comprised less than 10% of the texts.

Rapid automatized naming. A ‘stimulus card’ consisted of five letters (O, A, S, T, P) arranged in 5 rows by 10 columns. The stimuli were presented in pseudorandom order, yet no individual stimulus was immediately repeated (Ahonen, Tuovinen, & Leppäsaari, 1999).

Training.

Implementation. The training period consisted of ten (5 to 10 minute) computer training sessions in a 2-3 week period, with three to five sessions per week. Thirty practice syllables were randomly repeated five times during each session, resulting in 50 repetitions per syllable during the training period. By means of a computer program (for a detailed description of the program, see Lyytinen, Erskine, Kujala, Ojanen, & Richardson, 2009), a participant heard an auditory stimulus via headphones and then chose the corresponding syllable as quickly as possible from five written options on the computer screen. The child received feedback according to the speed of accurate responses. A new trial immediately followed each answer. Feedback comparing the child’s recognition speed to his or her previous sessions was given by the program after each training session.

Training materials. Trained syllables consisted of two-letter syllables, as well as frequent and infrequent four-letter syllables (Table 3), with each of the three types of syllables including 30 items. Two-letter syllables were matched with frequent four-letter syllables, according to their frequency in newspaper text (Department of General Linguistics, University of Helsinki, and Research Institute for the Languages of Finland, 1996-1998). Altogether, frequent four-letter syllables comprised 24% and infrequent four-letter syllables 0.06% of all occurrences of four-letter syllables in common texts. Four-letter frequent and infrequent syllables were matched according to their structure. None of the syllables had a semantic meaning.

During the intervention, as a control for the general effect of training and teacher attention, the control group practiced simple addition, subtraction and multiplication tasks using the same computer program. Each participant heard a number and was asked to select a corresponding equation presented on the screen. Feedback was based on the accuracy of the answer; speed was not emphasized. After the post-training test, teachers were encouraged to also use the *reading* training program of their choice with the control group children.

Table 3 about here

Results

Pre-Training Measurements

As children with very low reading accuracy were excluded and the accuracy measures were close to the upper limit in the pre- and post-test data of all groups (see Table 2), only reading speed was included in statistical analyses. Distributions of speed measurements were skewed and thus normalized using natural logarithmic transformations. This procedure did not change the pattern of the results; these were comparable between the original and the transformed data. Crosstabulation for gender (categorical) and analyses of variance for continuous pre-training measures (Table 1) revealed no differences between the groups (2L, 4LF, 4LI, and No training) in gender, [$\chi^2(3) = 1.45$, $p = .693$], age [$F(3, 146) = 1.38$, $p = .252$], naming speed [$F(3, 146) = 0.52$, $p = .666$], or in any of the reading speed measurements (two-letter syllables: [F(3, 146) = 1.11, p = .346], four-letter frequent syllables: [F(3, 146) = 1.38, p = .252], four-letter infrequent syllables: [F(3, 146) = 0.65, p = .586], pseudowords containing two-letter syllables: [F(3, 146) = 1.50, p = .218], pseudowords containing four-letter frequent syllables: [F(3, 146) = 0.60, p = .615], pseudowords containing four-letter infrequent syllables: [F(3, 146) = 1.33, p = .267], and text reading [F(3, 146) = 0.96, p = .413]). Finally, to explore the effect of syllable frequency, the reading speed of four-letter frequent and infrequent syllables was compared to each other over all groups at the beginning of the training. The results showed that the four-letter frequent syllables were read significantly faster than the four-letter infrequent syllables [t(149) = 11.58, p < .001].

Reading Speed Regarding Trained Syllables

To test the training effect, the reading times for syllable lists were analyzed using mixed model ANOVAs in which the Training condition (2L, 4LF, and 4LI in contrast to No training) served as a *between-subjects* factor and Time (pre-test and post-test) as a *within-subject* factor. Completion time for the list of trained syllables was used as a dependent variable to measure the training effect. The descriptive statistics of reading speed measures are presented in Table 1.

Significant Training condition x Time interactions were apparent when comparing the training groups with the control group (see Table 1), indicating greater gains in the training groups with respect to the speed of reading trained syllables: specifically, Group-2L in two-letter syllables [F(1, 81) = 5.84, p = .018, η_p^2 = .067]; Group-4LF in four-letter frequent syllables [F(1, 63) = 11.83, p = .001, η_p^2 = .158]; and Group-4LI in four-letter infrequent syllables [F(1, 70) = 25.22, p < .001, η_p^2 = .265]. No significant Training condition by Time interactions were apparent in regard to untrained syllables when comparing the training groups with the control group, indicating that the training effect was evident in trained but not in untrained syllables.

The interaction between the reading progress (Time) and the Training condition was further examined by means of the Johnson-Neyman procedure (Johnson & Neyman, 1936; Potthoff, 1964; Aiken & West, 1991). With this method, significance regions for the interaction were defined, producing limits beyond which differences between the training group and the control group were *significant.* With this method we were able to define the part of the training group that differed from the control group. The results revealed that the difference between the Group-2L and the control group in favor of the training group was significant in practiced syllables only for the 25% of participants who had been assessed as the poorest readers (at the pre-training stage). The corresponding figures for Group-4LF and Group-4LI were 77% and 73%, respectively.

Item-specific and Transfer Effects

Syllables. To test item-specificity at syllable level, development between pre-test and post-test (Time) of the three training groups (2L, 4LF, and 4LI) was compared in all syllable types (Table 1). For two-letter syllables, the differences between Group-2L and the other training groups were not straightforward. The only comparison approaching significance was between Group-2L and Group-4LI, where [$F(1, 83) = 3.59$, $p = .062$, $\eta_p^2 = .041$]. In terms of the development of reading speed of four-letter *frequent* syllables, Group-4LF outperformed the two other groups (Group-4LF vs. Group-2L: [$F(1, 76) = 9.86$, $p = .002$, $\eta_p^2 = .115$], and Group-4LF vs. Group-4LI: [$F(1, 65) = 8.54$, $p = 005$, $\eta_p^2 = .116$]). Similar results were obtained regarding four-letter *infrequent* syllables in comparisons between Group-4LI and the other groups (Group-4LI vs.

Group-2L: [$F(1, 83) = 27.62$, $p < .001$, $\eta_p^2 = .250$], and Group-4LI vs. Group-4LF [$F(1, 65) = 15.16$, $p < .001$, $\eta_p^2 = .189$]). In sum, all training groups outperformed the control group with regard to the practiced syllables. With respect to long syllables, the training groups also differed from each other so that each training group outperformed the other groups in the trained syllables.

Pseudowords. To explore a transfer effect to larger orthographic units, the list completion times for the pseudowords containing trained syllables (Table 1) were analyzed using the mixed model ANOVAs in which the Training condition (2L, 4LF, and 4LI in contrast to No training) served as a *between-subjects* factor and Time (pre-test and post-test) as a *within-subject* factor. While a trend indicated that the trained groups had a greater increase in speed in reading pseudowords than the control group in long syllables (Group-4F vs. Control group: [$F(1, 63) = 2.04$, $p = .158$, $\eta_p^2 = .031$]), this was shown statistically significant only with pseudowords containing four-letter infrequent syllables (Group-4LI vs. Control group: [$F(1, 70) = 4.68$, $p = .034$, $\eta_p^2 = .063$], and Group-4LI vs. Group-4LF: [$F(1, 65) = 4.42$, $p = .039$, $\eta_p^2 = .064$]).

General reading speed. To explore the effects of training on the reading speed of the text including only few practiced syllables (Table 1), the development (pre-test – post-test) of text reading speed was compared between each group (2L, 4LF, 4LI, and Control) with mixed model ANOVA. No differences were observed between the groups [$F(3, 146) = 0.98$, $p = .407$, $\eta_p^2 = .02$], indicating comparable development between the control and training groups.

Initial Reading Speed and Rapid Automatized Naming

The connections of initial reading speed (i.e. combined reading time for pseudowords and text in the pre-training test) and rapid automatized naming (RAN) with gains in syllable reading speed were analyzed separately in each training group using a linear regression model (Table 4). Distributions of the variables were positively skewed (i.e. skewness differed from zero on .01 significance level; Tabachnick & Fidell, 2007) and thus normalized using natural logarithmic or square root transformation. Independent variables (RAN and initial reading speed) were first entered into analysis separately and then together (enter method) in order to measure their independent and shared variance in explaining the gains in reading speed (the training effect). RAN was positively related to the initial reading speed ($.52 < r < .66$), but was not associated with the training effect. Slow initial reading speed significantly predicted the better training effect for a group training two-letter syllables (Group-2L), but not for the other training groups. Even though the independent variables were correlated, multicollinearity was not present: the tolerance coefficients were 0.714, 0.538, and 0.678 (i.e. clearly greater than a common border value 0.2) in analyses for gains in Group-2L, Group-4LF, and Group-4LI, respectively.

Table 4 about here

Discussion

The aim of this study was to explore the effects of training and transfer of computerized syllable training on reading speed with regard to various types of syllables with poor readers in 2nd and 3rd grades, as well as to investigate the influence of initial reading speed and RAN on the training effect among these children. The results from a transparent language with a clear syllable structure (Finnish) reveal that the speed of reading trained syllables increased across all of the three training groups compared to the control group. The training effect was most pronounced for long infrequent syllables and least for short syllables. As expected, the effects of training did not transfer to other types of syllables or to text including only few practiced syllables. However, the expected transfer to larger units that included practiced items was less pronounced than in previous studies (Huemer et al., 2010). RAN predicted the initial reading speed, but had no connection to the effect of training. Initial reading speed only predicted increases in the reading speed of short syllables.

The results showed that after repeated identification of syllables, all three training groups had more increases in syllable reading speed than the control group. This effect was evident already after a brief training (amounting to 1-2 hours of practice), indicating that computer-based syllable recognition may be a promising tool for increasing the reading speed of practiced items for slow readers soon after the first school year in an orthographically transparent language.

The results confirmed our set of hypotheses concerning the frequency effect of syllables. First, frequent syllables were initially read faster than similar but infrequent syllables. This supports the hypothesis of there being a facilitating effect of syllable frequency on reading speed (Perea & Carreiras, 1998). Second, slower initial reading speed left more room for improvement, and hence the training effect was more pronounced for infrequent syllables [η_p^2 = .265] than for frequent syllables [η_p^2 = 158]. This result also supports the claim that the greatest gains in repeated reading can be expected during the first exposures to practiced items, as three or four repetitions have been reported to be sufficient in most cases for both typical and poor readers (Meyer & Felton, 1999), while the speed and accuracy of reading seem to reach their maximum after six repetitions (Lemoine et al., 1993). However, one should note that a greater amount of repetition may promote the retention and generalization of the training effects (Lemoine et al., 1993), especially in the case of dyslexia (Reitsma, 1983; Thaler et al., 2004). In sum, the training effect per se was stronger for infrequent syllables, compared to more frequent syllables, most likely due to less previous exposure. However, as we also found a significant training effect with more frequent items, we can expect that their effects on *general reading* may be even greater, as very few of the most frequent syllables comprise a substantial amount of the text (in Finnish, the 50 most frequent syllables comprise over 50 percent of the text). That said, one should note that these frequent items may be already automatized due to prior exposure and, for this reason, additional training may not cause any significant gain in reading speed for poor readers in grades 2 and 3 who have already passed the first stages of reading development. Therefore, the selection of trained units should be planned carefully in order to promote an increase in both item-specific reading speed and a transfer to general reading.

In a comparison between short and long syllables, matched according to their frequency, the expected trend for longer syllables showing a greater training effect was confirmed ($\eta_p^2 = .158$ for long and $\eta_p^2 = .067$ for short syllables). In addition, for two-letter syllables, the difference in gains between the training group and the control group was only evident in the poorest quarter of the sample; for four-letter syllables, the difference was evident for three-quarters of the training group. This suggests that two-letter syllables were already automatized in most of the second- and third-graders in our sample. Therefore, further practice of two-letter syllables only helped the *extremely* slow readers. The increase of speed in reading long syllables probably indicates both automatization and a shift from serial letter-by-letter processing to a more holistic strategy of recognizing the syllable as a unit, which is in accord with the hypothesis of the self-teaching mechanism (Share, 1995). This finding is similar to studies that report a decreased length effect after practice (e.g. Maloney et al., 2009). Maloney et al. suggest that this effect does not reflect the strengthening of grapheme-phoneme associations, but rather a repetition-induced use of whole-item print-to-sound associations. Therefore, the syllable-length effect is due to another, more effective parallel strategy for reading.

In terms of generalization, the training effect did not transfer to untrained Finnish syllables or to text that did not contain a large amount of practice items among the sample of poor readers in grades 2 and 3. Our results are in line with previous results which show that the effects of fluency training are item-specific (Berends & Reitsma, 2006; Lemoine et al., 1993; Marinus et al., 2012; Thaler et al., 2004). However, in an earlier study examining repetitive syllable training, a transfer effect to larger units was demonstrated with long infrequent syllables (Huemer et al., 2010). Although in our study we also found a trend towards generalization to larger units above the practiced level (pseudowords containing practiced syllables), the effect was only significant with respect to infrequent syllables and the effect sizes were considerably lower than in the earlier study. We will discuss the possible explanations later.

Finally, the connection of initial reading speed and RAN to the training effect was explored. As expected, RAN was correlated with initial reading speed in line with previous studies which have shown the connection between slow naming and slow reading (Holopainen et al., 2001; Lervåg & Hulme, 2009; Savage & Frederickson, 2005). Contrary to studies in which slow naming hindered the results of reading intervention (Compton, 2000; Stage et al., 2003), but in accord with the studies by Berends & Reitsma (2006) and Levy et al. (1997), RAN showed no direct influence on the training effect when initial reading speed was accounted for.

Initial reading speed was associated with progress in reading speed for short but not long syllables in Finnish. Analysis revealed that the participants who gained the most from the training were the slowest of the poor readers. This is rather easy to understand in light of the results presented before: that is, most participants had increases in reading speed with respect to long syllables (regardless of initial reading speed), but with respect to short syllables, the increases were evident only among the slowest readers. One of the most appealing explanations for this is very simple: even though there is no absolute ceiling for reading speed, development in speed reaches its “asymptote” sooner or later (Breznitz, 2006). The slowest readers have the most room for improvement, as the faster readers may already have been close to this asymptote at the beginning of the experiment. This most probably explains the differences in development between the limits of the range of initial reading speed. Given the lesser effects of training and that the initial reading speed of the fastest readers reached the average of typical readers in general reading speed (compared to JLD data, Torppa et al., 2010), this explanation seems plausible for this sample. However, this does not mean there is no advantage of training even for the faster part of the group, as there was still a variation in gains with these children. For *long items*, for example, the majority (77% and 73% of the 2nd and 3rd graders practicing frequent and infrequent long syllables, respectively) of all the poor readers in our sample improved, not just those at the lowest level. It is encouraging to find that the poorest readers were actually not the most resistant to training, as has been previously reported (Berninger et al., 2002). Repeated syllable training seems to benefit children learning to read a transparent language with a clearly defined syllable structure.

Although the results of this study were promising with regard to gains in syllable reading speed, the training effect (η_p^2 = .27) was weaker than that seen in an earlier study assessing the effects of repeated reading practice with infrequent syllables (η_p^2 = .60 to .63; Huemer et al., 2010). There are several possible explanations for the difference in results. First, training specific syllables using silent recognition may be less effective than reading them aloud. One explanation could be that active naming requires higher engagement and attention, compared to more passive recognition (Thaler et al., 2004). This notion is supported by the findings of Hintikka et al. (2008), where training methods similar to ours produced a comparable effect size [η_p^2 = .29] in consonant cluster recognition in German (Hintikka et al., 2008). This possible disadvantage of recognition tasks could be compensated for by prompting the reader for overt vocalization of responses, or by simply increasing the amount of practice. The effectiveness of different training methods—such as oral reading, silent reading and silent recognition—should also be explicitly compared, especially since consensus on the superiority of any one method has not been reached (Berends & Reitsma, 2007; de Jong & Share, 2007; Share, 2008).

Another explanation for the weaker training effect in this study is related to the assessment. The outcome measurements used by Huemer et al. (2010) were similar to the training method they used, as both involved reading aloud. However, in our study (as well as the one done by Hintikka et al. (2008)), recognition tasks utilizing a computer were used in training sessions while test measures were based on reading aloud. Accordingly, transfer from recognition to reading aloud was required, something which may have affected the observed effects of training and made comparisons to previous studies more complicated. This could also explain the observed weaker transfer effect to pseudowords, compared to Huemer et al. (2010). A “double-transfer” was required in our study (that is, from syllables to pseudowords and also from recognition to reading aloud). In further studies, the transfer effect should be measured in more detail by assessing both silent recognition and reading aloud. Thus, a challenge for future research will be to develop tasks that reliably measure the silent recognition speed of sublexical items.

A limitation of the present study is the absence of standardized measurements for reading speed and IQ, since they are not available for teachers. Accordingly, the heterogeneity of the sample in regard to initial reading skills and IQ could not be fully explored, nor could a comparison between poor and typical readers be made in this study. However, the background information provided by parents and teachers was used when excluding children representing the extremes of reading skill levels and in alleviating the bias caused by heterogeneity. Also, a comparison with the well-documented Finnish data of typical and dyslexic readers (Torppa et al., 2010) verified the positioning of the sample in terms of the distribution of reading performance.

In further studies, it would be worth exploring if the observed training effects are specifically related to syllable-level processing or if they could also be found with other sublexical units that are common in the orthography (e.g. suffixes, common letter combinations). Our present study and the study by Huemer at al. (2010) addressed syllable training directly without promoting generalization per se. In future studies, the factor of transfer to word and text levels should be addressed within the framework of syllable training, perhaps moving in the direction of the subsyllabic method of text reading (Tressoldi et al., 2007). We also acknowledge that syllable training on its own is not very motivating, and in practical applications of this approach, multifaceted methods should be used to promote both motivation and transfer. Because the ultimate goal of fluent reading is comprehension, we will need to measure the effects of fluency training not only in terms of reading speed but also reading comprehension.

In summary, this study has shown the promising effects of syllable training for poor readers in grades 2 and 3 in a transparent language with a clear syllable structure (Finnish), indicating item-specific associations between print and sound during independent reading practice, even with respect to larger sublexical items than letters. In the future, more attention needs to be paid to finding effective means of supporting transfer to everyday reading contexts. Slow naming and slow reading speed did not seem to hinder the training effects, which is a promising result for educators working with poor readers.

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Table 1.

Reading and Naming Times (Means and Standard Deviations) Showing Results from Pre- and Post-Training Tests by Groups

	Group-2L (*n* = 48)		Group-4LF (*n* = 30)		Group-4LI (*n* = 37)		Control Group (*n* = 35)	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Male (%)	60.4		66.7		54.1		54.3	
Age (in years)	9.09 (0.69)		9.24 (0.64)		9.12 (0.66)		9.38 (0.75)	
RAN (letters)	39.1 (8.7)		37.3 (9.1)		37.7 (8.4)		37.1 (8.1)	
Reading times (sec/item)								
2L-Syl	0.97 (0.24)	0.81 (0.18)	0.90 (0.19)	0.78 (0.17)	0.96 (0.22)	0.86 (0.18)	0.90 (0.22)	0.83 (0.23)
4LF-Syl	1.45 (0.46)	1.27 (0.36)	1.29 (0.41)	1.02 (0.34)	1.39 (0.45)	1.23 (0.41)	1.30 (0.43)	1.18 (0.42)
4LI-Syl	1.63 (0.58)	1.43 (0.45)	1.48 (0.51)	1.26 (0.41)	1.56 (0.57)	1.14 (0.46)	1.51 (0.53)	1.32 (0.51)
2L-Psw	1.97 (0.63)	1.81 (0.58)	1.71 (0.53)	1.58 (0.54)	1.85 (0.67)	1.80 (0.66)	1.74 (0.57)	1.66 (0.58)
4LF-Psw	2.34 (0.74)	2.23 (0.71)	2.18 (0.70)	1.97 (0.64)	2.26 (0.80)	2.18 (0.82)	2.15 (0.74)	2.04 (0.69)
4LI-Psw	2.58 (0.80)	2.34 (0.75)	2.34 (0.83)	2.22 (0.77)	2.46 (0.95)	2.16 (0.87)	2.27 (0.82)	2.14 (0.75)
Text (sec/word)	2.06 (0.92)	1.96 (0.85)	1.83 (0.95)	1.60 (0.71)	2.01 (0.89)	1.82 (0.78)	1.82 (0.76)	1.71 (0.74)
(sec/syllable)	0.71 (0.32)	0.68 (0.29)	0.63 (0.33)	0.56 (0.25)	0.69 (0.31)	0.63 (0.27)	0.71 (0.32)	0.60 (0.26)

Note. Group-2L practiced two-letter syllables (2L-Syl), Group-4LF practiced four-letter frequent syllables (4LF-Syl), and Group-4LI practiced four-letter infrequent syllables (4LI-Syl). Psw = pseudowords; 2L-Psw are pseudowords, including trained two-letter syllables, etc.; RAN = rapid automatized naming.

Table 2.

Reading Accuracy Percentage (Means and Standard Deviations) Showing Results from Pre- and Post-Training Tests by Groups

	Group-2L (*n* = 48)		Group-4LF (*n* = 30)		Group-4LI (*n* = 37)		Control Group (*n* = 35)	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
2L-Syl	97.4 (3.3)	97.6 (4.4)	98.1 (2.7)	97.0 (3.5)	97.3 (4.0)	97.0 (4.5)	96.5 (5.2)	97.0 (5.1)
4LF-Syl	92.9 (8.6)	95.5 (5.2)	95.0 (5.7)	98.2 (3.6)	94.4 (5.7)	95.2 (5.7)	94.4 (5.9)	95.0 (5.3)
4LI-Syl	90.5 (8.1)	92.1 (7.4)	92.7 (7.5)	93.2 (7.6)	90.3 (8.0)	95.0 (5.6)	90.0 (9.5)	91.7 (10.7)
2L-Psw	87.0 (8.8)	88.8 (9.0)	87.4 (7.5)	89.0 (11.1)	86.9 (11.7)	88.7 (11.0)	84.7 (11.3)	85.6 (11.4)
4LF-Psw	85.4 (10.6)	87.1 (10.5)	85.6 (14.6)	90.6 (9.1)	86.3 (11.8)	86.2 (13.2)	83.3 (13.7)	86.6 (12.9)
4LI-Psw	78.6 (12.9)	81.0 (12.3)	78.1 (13.7)	85.8 (10.2)	81.6 (12.3)	87.8 (9.6)	78.6 (14.3)	84.4 (14.1)
Text (sec/word)	86.3 (9.7)	88.5 (7.2)	89.5 (7.1)	91.3 (5.5)	89.1 (7.5)	90.9 (5.5)	89.0 (6.6)	92.1 (4.3)

Note. Group-2L practiced two-letter syllables (2L-Syl), Group-4LF practiced four-letter frequent syllables (4LF-Syl), and Group-4LI practiced four-letter infrequent syllables (4LI-Syl). Psw = pseudowords; 2L-Psw are pseudowords, including trained two-letter syllables, etc.

Table 3.

Syllable Characteristics per Training Condition.

Condition	Length	Frequency	Structure (n)	Examples
2L	2 letters	1.945%	VV[a] (1)	äi
			CV (16)	nu, re, sö
			VC (14)	ak, ul, äs
4LF	4 letters	1.956%	CVCC (3)	kans, ment, vält
			CVVC (15)	viik, keen, muus
			CVVC[a] (12)	muis, siel, jouk
4LI	4 letters	0.005%	CVCC (3)	tyrs, punt, hömp
			CVVC (15)	kiik, leet, noon
			CVVC[a] (12)	sius, teip, mouh

Note. 2L= Two-letter syllables, 4LF = Four-letter frequent syllables, 4LI= Four-letter infrequent syllables. Frequency = percent comprised by the category of all syllables in a common text (Department of General Linguistics, University of Helsinki, and Research Institute for the Languages of Finland, 1996-1998). Structure = order of vowels (V) and consonants (C) within the syllable. Note that none of the syllables included digraphs.

[a]diphtong

Table 4.

Regression Analyses Predicting Gains in Reading Speed of Syllables: Unique and Shared Variance for Rapid Automatized Naming and Initial Reading Speed

	Group-2L (*n* = 48)		Group-4LF (*n* = 30)		Group-4LI (*n* = 37)	
Gain Syllables	β	R^2	β	R^2	β	R^2
Model 1: RAN	-.080	.006	-.278	.077	.052	.003
Model 2: IR	-.365*	.133	-.177	.031	.018	.000
Model 3: RAN and IR	.162[a]/-.451[b]*	.152	-.294[a] /.023[b]	.078	.062[a] /.017[b]	.003

Note. Gain syllables = Gain in reading speed of practiced syllables from pre- to post-training test.

Group-2L practiced two-letter syllables, Group-4LF practiced four-letter frequent syllables, and Group-4LI practiced four-letter infrequent syllables. RAN = rapid automatized naming of letters; IR = initial reading time for pseudowords and text (i.e. prior to intervention).

[a]Standardized Beta-coefficient for RAN¸ [b]Standardized Beta-coefficient for IR.

*p < .05, **p < .01, ***p < .001