Efficacy of an Intervention to Improve Fluency in Children With Developmental Dyslexia in a Regular Orthography

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Abstract

The purpose of this study was to examine the efficacy of a method to improve reading fluency in children with dyslexia. The method, which we named "subsyllabic," was aimed at automatizing the recognition of syllables within words in connected texts, presented by ad hoc software. Two versions of this method—one self-paced and the other one with automatic syllable identification—were compared to a method based on phonemic awareness, assisted reading, and other psycholinguistic exercises. The efficacy of the two versions of the subsyllabic method was further studied by repeating the first version twice and the second version three times using an AB design, with each phase lasting approximately 3 months. This part of the study provided not only follow-up data but also useful information on if and how fluency may change after repeated treatment. Outcomes obtained by a total of 63 children with dyslexia suggested that the subsyllabic method was superior to the control method and that the use of an automatic presentation of target syllables produced better results. Furthermore, we observed that fluency improved approximately at the same rate after each treatment repetition. Our data support the possibility of improving reading fluency at a significant clinical level, at least for regular orthographies. The crucial component of the subsyllabic method seems to be the facilitation of syllable recognition within words in connected texts and the emphasis on their rapid recognition using an automatized procedure.

Efficient reading must be accurate but also fluent. In the remediation of reading disabilities (RD), this characteristic has not been the first aim of many intervention studies, but its importance has been widely recognized. However, very few clinical trials have reported on the efficacy of improving reading fluency in children with developmental dyslexia. As Lyon and Moats (1997) wrote, "it also critical to recognize that in all of the NICHD intervention studies to date, improvements in decoding and word-reading accuracy have been far easier to obtain than improvements in reading fluency and automaticity" (p. 579). This situation was confirmed by the meta-analysis of Necoechea and Swanson (2003), where it was found that 90% of the studies included standardized dependent measures of real word reading accuracy and none included measures of fluency.

A recent meta-analysis by Chard, Vaughn, and Tyler (2003) on interventions to improve reading fluency in students with learning disabilities identified 24 studies from 1975 to 2000, including both group studies and single-case studies. The mean effect sizes for the different intervention categories were in the moderate range (.68 for repeating reading without a model; .71 for repeating reading with multiple features), according to Cohen's (1988) criteria. However, it is important to note that few studies used standardized instruments such as the *Gray Oral Reading Test* or the *Schonell Word Recognition Test* to document their results. The same problem was observed in Kuhn and Stahl's (2003) review of remedial practices for fluency with both low-achieving children and children with learning disabilities.

If fluency is an important goal in the treatment of RD in languages with irregular orthographies, it is the main goal for those with regular orthographies. Cross-linguistic comparisons between typical readers show clearly that accuracy is usually almost perfect after some months of general education for Italian and German readers, whereas English or Danish readers are still struggling to assimilate the orthography–phonology rules (Seymour, Aro, & Erskine, 2003). A direct comparison between German and English children with dyslexia by Landerl, Wimmer, and Frith (1997) showed that for English children with dyslexia, the average error rate was still as high as 30% to 40% for short one- and two-syllable words and nonwords, whereas

German children with dyslexia had an average error rate of less than 10% on a closely matched set of items.

Even though German children with RD could develop high reading accuracy, their reading remained slow and laborious (Wimmer, 1993, 1996). Wimmer and Mayringer (2002), for example, reported a standard word reading rate of between 170 and 190 syllables per minute in 9-year-old typical German-speaking children, whereas different samples of children with RD only managed to read between 70 and 95 syllables per minute on the same set of words. Similar findings of high reading accuracy but deficient reading fluency in children with dyslexia have also been reported for other languages with regular orthographies such as Norwegian (Lundberg & Hoien, 1990), Spanish (Rodrigo & Jimenez, 1999), Dutch (Yap & van der Leij, 1993), or Italian (Zoccolotti et al., 1999).

The deficit in reading fluency is not only a serious impairment but also highly persistent. Klicpera and Schabmann (1993) showed that the majority of German-speaking children with a reading fluency deficit in Grade 2 still presented seriously delayed reading speed in Grade 8. The most likely explanation for reading problems in German is the aforementioned deficit in the buildup of orthographic representations that would allow children to move on from accurate but slow and laborious decoding to direct and therefore fast and effortless word recognition. Tressoldi, Stella, and Faggella (2001) reported similar findings in a longitudinal study with a sample of 38 Italian children with dyslexia from the second to the eighth grade. Tressoldi et al. found that children with dyslexia increased their reading fluency in a connected text at a mean rate of 0.3 syllables per second per year, corresponding approximately to 9 words per minute (wpm) per year, a rate almost half that of typical readers and comparable to their development in nonword reading, suggesting that their principal impairment was similar to the one described by Klicpera and Schabmann (1993).

Such an association problem could be the consequence of a slow and inefficient phonological lexicon (Snowling, 2000) or of a more general neurological timing problem preventing visual and phonological areas from getting activated at the same time (Breznitz, 2002; Breznitz & Lauren Berman, 2003; Paulesu et al., 1996; Wolf & Bowers, 1999). According to this hypothesis, dysfluent readers have a deficit in storing words or parts of words in the orthographic lexicon as a consequence of a lack of multiple, redundant associations between the single graphemes and grapheme clusters of word spelling and the single phonemes or larger morphophonological segments (e.g., syllables, morphemes, onsets, rimes) of word phonology. If this explanation is correct, then it should be possible to help poor readers to build up orthographic representations by highlighting the correspondences between the visual/graphemic and the phonemic and phonological elements within words.

The aim of the present study was to explore if a reading method facilitating the identification of syllables—the sublexical units that are more consistent in regular orthographies (Carreiras, Alvares, & De Vega 1993; Carreiras & Grainger, 2004)—could be applied to help a sample of Italian children with dyslexia to build up orthographic representations of recurrent syllables to achieve faster, automatic direct word recognition. In Italian, the correspondence between syllables and phonology approximates 99% regularity. For example, the syllable *pa* is pronounced /pa/ in whichever word and position, as in *patate* (potatoes), *scarpata* (escarpment), or *scarpa* (shoe).

The choice to present syllables within connected texts was justified by evidence that supported better generalization if words are presented in context than in lists. Martin-Chang and Levy (2005), for example, showed that training words in context, as compared to training in isolation, led to the faster reading of those words when they were later encountered in a new context both for good and poor readers. Furthermore, Tressoldi, Vio, and Lonciari (2000), who trained Italian children with dyslexia to read isolated words faster, thus facilitating syllable recognition, did not obtain significant fluency generalization in reading text.

The study questions were as follows:

1. Is it possible to achieve superior fluency results with our method compared to results obtained by a comparative method based on a different approach?
2. Is it possible to obtain continuous gains in reading fluency after treatment replications?

The second question is quite unexplored by current research. Usually, most published research has reported the outcomes after a single intervention, sometimes with only a single follow-up. Because it is quite unlikely to expect fluency normalization even after some months of intervention, it is interesting to explore what fluency gains can be obtained by replicating the intervention.

The goals of this study were realized by comparing two versions of our method, named *subsyllabic*, with a second method based on a different rationale and replicating only the two versions of our method using an AB design with two and three replications, respectively.

The two versions of the subsyllabic method we defined—self-paced (SP) subsyllabic and automatic (Aut) subsyllabic—differed only in the modality used to present the target syllable. In the SP version, the syllable to be identified was presented at a self-paced rate, whereas in the Aut version it was presented at a fixed rate. This variation was implemented to verify the importance of the rapid identification of syllables to automatize their recognition. The direct comparison between these two versions of the subsyllabic method has to be considered exploratory in the first part of the study and confirmatory in the second part.

Method

Participants

Sixty-three children (41 boys, 22 girls) attending primary and secondary school from the end of the second grade to the end of the eighth grade were recruited for the study. Participants were enrolled if they satisfied the criteria for a diagnosis of dyslexia according to the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (*DSM-IV*; American Psychiatric Association, 1994), criteria controlled after a clinical interview and a reading evaluation with the *MT Battery* (Cornoldi, Colpo, & Gruppo MT, 1998), the Italian normed test for the assessment of accuracy and fluency in reading text with the best psychometric properties. This evaluation was completed by certified clinical psychologists affiliated with three different public clinics in three different locations in Italy. The participants' main initial characteristics are presented in Table 1 separately for the three samples.

There were no statistically significant differences on reading fluency or chronological age among the three groups. Only the percentage of errors differed statistically between the linguistic and subsyllabic SP groups on the one hand and the subsyllabic Aut group on the other, $F(2, 60) = 7.2$, $p = .001$.

It is important to point out that the reading fluency of all participants was at least 2 *SD* below that of typical readers according to the norms of the standardized test used. A percentage of errors below 5% is considered within the normal limits. In this sense, the accuracy level of both the linguistic and the subsyllabic SP groups may be considered nonpathological.

Design

The first part of the study was a controlled trial designed to verify the relative efficacy of each of three treatment methods. It consisted of a pretest, a training phase, and a posttest within one week after the last training day.

The second part of the study was a multiple AB (treatment–no treatment) design of the application of the two versions of the subsyllabic method, with two and three replications, respectively. This second part of the study enabled us to obtain follow-up measures and, even more important, a demonstration of the efficacy of successive applications with these intervention methods.

Procedure

A parent's permission was obtained for each participant admitted to the study. Given the distances among the three clinics, it was not possible to assign participants randomly to the three methods of intervention. We thus assigned participants to the three intervention methods according to their ability to attend the clinic closest to their home. Each clinic delivered a different type of treatment.

Participants in the *linguistic* method were invited to attend the clinic twice a week for 45 min. The treatment was applied by certified speech therapists. This method consisted of different exercises to improve phonemic blending and synthesis and assisted reading of isolated words and simple texts, with feedback in case of errors, but no systematic exercises to recognize syllables either in isolation or embedded in words.

Participants in the two subsyllabic methods were requested to attend the clinic once a week during the first month and once every two weeks in the remaining period. During this time, the therapist, usually a certified psychologist, taught the participants and their parents the exercises to practice at home for at least 10–15 min a day for 5 days a week. The exercises consisted in reading text using special Reader® or WinABC software (see *http://www.impararegiocando.it/winabc50* for more details) that allowed the presentation of texts of every length, difficulty level, and content, facilitating the visual identification of each syllable (i.e., inserted in a box or colored differently). For example, with the word *giornata* (day), the identification of the three syllables could be facilitated as follows: *giornata, giornata, giornata*. An important detail is that the shift of the target syllable from left to

TABLE 1
Initial Demographic and Reading Characteristics by Group

	Linguistic[a]		Subsyllabic SP[b]		Subsyllabic Aut[c]	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*
Chronological age	8.2	1.1	8.0	0.9	9.3	1.4
Grade range	2–6		2–6		2–7	
Gender						
Boys	12		10		19	
Girls	7		7		8	
MT Reading						
Fluency[d]	1.13	0.45	1.04	0.52	1.16	0.58
Errors (%)	5	4	5	5	9	5

Note. SP = self-paced; Aut = automatic; MT = *MT Battery* (Cornoldi et al., 1998).
[a] *n* = 19. [b] *n* = 17. [c] *n* = 27. [d] Syllables per second.

right could be obtained either at a self-paced speed, pressing the space bar of the computer keyboard, or automatically after a precise interval chosen by the therapist, taking into account the reading fluency of each participant. The participant was invited to read the text accurately and as fast as he or she could, but still pay attention to its content. If the advancement of the target syllables was self paced, the participant was invited to aim for the velocity goal defined by the therapist. If the syllable advancement was automatic, the participant was invited to maintain the fluency imposed by the computer. Reading errors were registered by an assistant and used for subsequent feedback. When the participant met the fluency goal with an acceptable number of errors, the therapist increased the velocity goal gradually, usually adding 0.2 syllables/second at each increment.

Dependent Variables

The dependent variables were reading fluency and accuracy, always assessed using normed passages of the *MT Battery*. Each participant was tested individually and required to read the passage selected according to his or her grade level, "as fast and accurate as possible paying attention to the content." Each passage consisted of a text of about 200 words. Maximum reading time allowed was 4 min. Fluency is expressed in syllables per second (syll/sec; see Note) as is customary in Italy, accuracy as percentages of errors corresponding to words read violating the correspondences between orthography and phonology.

Treatment Integrity

To check the correct application of the treatment at home, each child was required to keep a diary of the amount of time spent and the type of exercises completed with the supervision of his or her parents. During the periodic controls at the clinic, therapists verified the results obtained at home by interviewing the parents and testing the same exercises.

Results

Comparative Study

The pretest, posttest, and gain scores of fluency and accuracy in reading a passage using the standardized test are presented in Table 2. At posttest, all groups obtained average scores corresponding to a typical accuracy level. A larger accuracy gain was obtained among the subsyllabic methods by the Aut method—simply because this group had a higher percentage of errors at pretest—whereas the subsyllabic SP method and the linguistic method obtained a similar, smaller improvement, but still at the typical level.

Gains in fluency were different among the three methods. As presented in Table 2, the linguistic and the subsyllabic SP methods obtained almost the same improvement, though the former after a mean of 5 months and the latter after a mean of 3 months of treatment. Their effect sizes were not statistically different. The best results were obtained by the subsyllabic Aut method. Gains obtained with this method were clinically and statistically superior to those obtained by the subsyllabic SP and the linguistic method, $F(2, 60) = 7.5$, $p = .0011$, $\eta^2 = .20$.

Treatment Replications

Figure 1 presents the mean changes in fluency at each evaluation with the application of the subsyllabic SP and subsyllabic Aut method after two and three treatment replications, respectively. Accuracy was controlled but not reported, because it was within the typical range. Each treatment and interval period lasted approximately 3 months. The procedure was identical to that used in the first comparison study.

As is evident from the visual inspection, reading fluency increased at almost the same average amount only during the treatment replication periods. In fact, the change in reading fluency was on average $M = 0.24$ syll/sec ($SD = 0.17$) after treatment during the two replications of the subsyllabic SP intervention, whereas the change was only $M = 0.05$ syll/sec ($SD = 0.57$) during the interval period, corresponding

TABLE 2
Reading Fluency and Error Scores at Pre- and Postintervention With Effect Sizes by Treatment Group

		Duration				Fluency (syll/sec)							Errors (%)						
		Months		Hrs/month		Pretest		Posttest		Gain			Pretest		Posttest		Gain		
Treatment	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*ES*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*ES*
Linguistic	19	5.4	1.1	4.1	0.3	1.13	0.45	1.41	0.42	0.28	0.32	.63	5	4	4	3	1	4	.46
Subsyllabic																			
SP	17	3.0	1.2	5.0	0.7	1.04	0.52	1.31	0.59	0.24	0.21	.39	5	5	5	7	0	5	.00
Aut	27	3.4	2.3	4.8	1.2	1.16	0.58	1.68	0.71	0.53	0.27	.73	9	5	4	3	5	4	.90

Note. SP = self-paced; Aut = automatic. Reading fluency and error scores obtained by the standardized passage reading test of the *MT Battery* (Cornoldi et al., 1998).

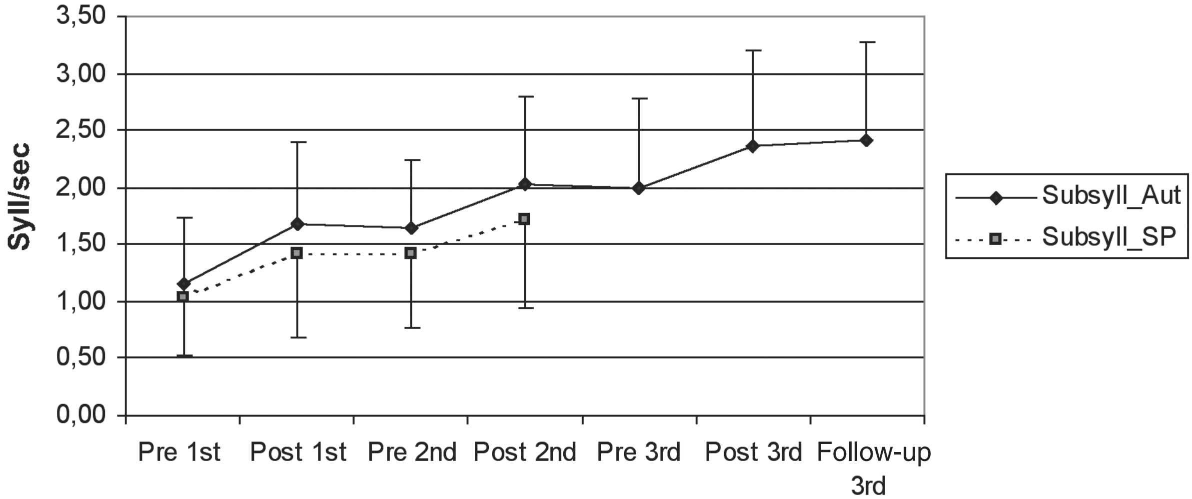

FIGURE 1. Evolution of text reading fluency (syllables per second) during treatment repetition with the subsyllabic self-paced (Subsyll_SP) and subsyllabic automatic (Subsyll_Aut) methods. Data points represent means and error bars represent standard deviations.

to an effect size of *d* = 0.49. With the subsyllabic Aut method, the average reading fluency gain was *M* = 0.42 syll/sec (*SD* = 0.17) during the three replications of the treatment, versus *M* = 0.005 syll/sec (*SD* = 0.10) during the no-treatment periods, corresponding to an effect size of *d* = 3.0. The direct comparison between the two methods confirms the superiority of the subsyllabic Aut versus the subsyllabic SP method (*d* = 1.05; 95% confidence interval = 0.12–1.99) observed in the first part of the study.

Evidence that fluency improvement is associated with the amount of treatment was obtained from the correlation between the number of hours of treatment and the change in reading fluency (see Table 3). Even though these correlations explain only approximately half the variance of the changes in reading fluency obtained during the treatment, they give strong support to the well-known finding that automatization is linearly dependent on the amount of training.

TABLE 3
Correlation (Pearson *r*) Between Duration of Treatment and Change in Reading Fluency

Treatment duration	Change in fluency
Subsyllabic self-paced	
1st intervention	.77
2nd intervention	.72
Subsyllabic automatic	
1st intervention	.73
2nd intervention	.75
3rd intervention	.56

Discussion

With a treatment aimed at facilitating the automatization of syllable recognition, children with dyslexia improved on average 0.24 syll/sec (ca. 6.5 wpm) using a self-paced and 0.42 syll/sec (ca. 12 wpm) using an automatic version of the method targeting syllable advancement after 3 months of treatment. These changes were replicated by repeating the respective interventions two and three times after a period of no treatment, suggesting that with appropriate training, it seems possible to continue to improve reading fluency. It is clear that without experimental evidence, it is not possible to predict which level can be attained and whether the normalization of the reading fluency of children with dyslexia is possible. At any rate, our results offer good evidence of the plasticity of the impaired reading process in dyslexia under specific and continuous training.

The clinical relevance of these changes is that they are superior to those obtained with a control treatment that lacked an emphasis on the systematic facilitation of the automatic recognition of syllables—the method we called linguistic—and to the reading development expected in children with dyslexia without specific treatment (Tressoldi, Stella, & Faggella, 2001). The superiority of the automatic version relative to the self-paced version of the subsyllabic intervention is clearly due to the difference between the self-paced and the automatic advancement of the target syllable. This result is compatible with the data obtained by Breznitz (1997) with her acceleration procedure. Her data indicated that, like typical readers, with the acceleration manipulation, the readers with dyslexia could read faster than their self-paced routine reading rate. The children with developmental dyslexia benefited the most from an accelerated reading rate. By forcing the readers to read faster, the readers with developmental dyslexia read about

25% faster than their typical routine reading rate

These results are more encouraging than those obtained by Tressoldi, Vio, and Lonciari (2000) with Italian children with dyslexia and by Thaler, Ebner, Wimmer, and Landerl (2004) with German poor readers. These different outcomes may be explained by their use of isolated words instead of connected ones and, only for Thaler et al., by their emphasis on onsets instead of syllables, their request to pronounce the target onsets not only simultaneously but also grapheme by grapheme, their lack of emphasis on recognizing words as fast as possible (e.g., using a tachistoscopic presentation), and probably also by the differences in the amount of training—25 sessions in almost one month versus about 75 in 3 months in our case. Only direct comparative studies could clarify which variables may be the cause of the differences observed. We suggest that the facilitation of the visual identification of the syllables in words inserted in connected texts and the emphasis on their rapid recognition obtained by presenting them at an automatized rate (e.g., a tachistoscopic presentation) may be the two crucial ingredients to improve fluency at a faster rate, as we observed comparing the subsyllabic self-paced and subsyllabic automatic results.

Our method received an indirect support from the simulation to model the successes and failures of interventions for individuals with RD implemented by Harm, McCandliss, and Seidenberg (2003). These authors stated that "the simulations broadly replicate the patterns of success and failure found in the developmental literature, and provide explicit computational insights into exactly why the interventions that include training on spelling–sound regularities are more effective than those targeting phonological development alone" (p. 155). Even though Harm et al. referred to English orthography and to treatments that were more focused on accuracy than on fluency, we think that their findings may be extended to regular orthographies as well as to the recovery of reading fluency.

The characteristic of facilitating the identification and the automatization of rapid orthographic units in our treatment is shared by other methods devised for less regular orthographies, like the RAVE-O program (Meyer & Felton, 1999; Wolf, Miller, & Donnelly, 2000), even if the choice of orthographic units is clearly different. In fact, Tijms, Hoeks, Paulussen-Hoogeboom, and Smolenaars (2003) obtained clinically meaningful reading accuracy and fluency improvements after the treatment and after a 4-year follow-up when training Dutch children with dyslexia to read words on a computer screen presented in various ways, including phoneme by phoneme (e.g., k/a/t, *cat*), onset–kernel–coda (e.g., kl/a/p, *slap*), or syllable by syllable (e.g., kat/ten, *cats*). The word components were highlighted at a pace that was adjustable to the individual's reading speed.

We are aware of the intrinsic limits to the internal validity of this study (i.e., lack of truly randomized allocation of participants to different treatments; differences in treatment application by parents and professionals), but we think they represent an acceptable compromise to enhance the external validity in order to represent real conditions commonly encountered when carrying out research in typical settings. If our findings are replicated with other regular orthographies, we could be more optimistic on the possibility of improving reading fluency and consequently reading efficiency at a level closer to school requirements, thus reducing the impairment of children with dyslexia.

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NOTES

1. *To convert syllables per second to words per minute (wpm), multiply by 60 and divide by 2.1 (average number of syllables per word).*

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