Efficacy and efficiency outcomes of a training to ameliorate developmental dyslexia using the online software Reading Trainer®

Renzo Tucci[1], Veronica Savoia[1], Laura Bertolo[2], Claudio Vio[3], Patrizio E. Tressoldi[4]

[1] *SPillo Studio di Psicologia e Logopedia, Verona*

[2] *ASL5 La Spezia, Servizio di Neuropsichiatria Infantile*

[3] *UOC Neuropsicopatologia dello Sviluppo, ULSS 10 San Donà di Piave (VE)*

[4] *Department of General Psychology, University of Padua*

ABSTRACT. In questo studio vengono presentati i risultati di un trattamento sublessicale e lessicale erogato tramite *Reading Trainer*, un software integrato nella piattaforma informatica online RIDInet, con una modalità di trattamento a distanza (svolto a domicilio), ma costantemente monitorato dal terapeuta. Sono stati coinvolti 34 bambini con una diagnosi di Dislessia Evolutiva. I risultati ottenuti nella correttezza e nella velocità di lettura di brano e di liste di parole e di non parole sono stati analizzati rispetto a un criterio di efficacia, corrispondente al cambiamento atteso senza interventi specialistici, e secondo un criterio di efficienza, corrispondente al cambiamento rispetto alle ore di trattamento, e confrontati con i risultati di alcuni studi italiani già pubblicati (Allamandri et al., 2007; Tressoldi & Vio, 2011; Tressoldi et al., 2012). I dati mostrano adeguati valori di efficacia ed efficienza e significative ricadute nel processo di automatizzazione della lettura, riportando ulteriori evidenze di validità del trattamento applicato tramite *Reading Trainer*.

SUMMARY. This study presents the results of a sublexical and lexical treatment provided through Reading Trainer™ software integrated in the online platform RIDInet, but constantly monitored by a clinical expert. Thirty-four children with a diagnosis of Dyslexia were enrolled in the study. The results obtained in the accuracy and speed in reading a passage, lists of words and nonwords were analyzed with respect to a criterion of efficacy, corresponding to the expected change without specialized training, and according to a criterion of efficiency, corresponding to the change of syllables/second for each hour of training. Results show adequate values of efficacy and efficiency and significant impact on the reading fluency and accuracy, bringing further evidence of the validity of the treatment applied by using the Reading Trainer™ software.

Keywords: *Developmental dyslexia, Training, Software, Efficacy, Efficiency*

INTRODUCTION

"*Scientific literature about the result of treatment to improve reading in dyslexic children represents less than 5% of the whole literature about Dyslexia*" (Tressoldi et al., 2003).

At the present situation hasn't changed much, anyway, in the last few years, in Italy some researches have been done that let us obtain useful information to understanding better which should be the characteristics of an effective and efficient rehabilitation, related to age of the patient and severity of his/her disorder.

Many different studies done from different investigators (Tressoldi et al., 2000; Judica et al., 2002; Tressoldi et al., 2003; Lorusso et al., 2004; Riccardi Ripamonti et al., 2004; Lorusso et al., 2005; Vio & Mattiuzzo, 2005; Lorusso et al., 2006; Lorusso et al., 2007; Allamandri et al., 2007; Tressoldi et al., 2012) underline how the most effective treatments are those that, at first, aim to reach the best accuracy in reading, without laying stress on fluency.

When a sufficient level of accuracy has been obtained, the training comprises exercises aiming at automatizing the process, preferably, through a method based on the rapid naming of sublexical units, particularly syllables and using preferably a complete text, not single reading units, presented through software especially devised for this type of training.

The result of these treatments have shown some important findings. Age seems not to be a penalizing factor for treatment. Hence you can obtain effective changes in reading up to the secondary school. Another important finding is that with approximately 7-8 hours of training distributed in about 2-3 months, it is possible to obtain clinically relevant changes (equal to or greater than that expected by a dyslexic child) both given by a professional who had specific clinical experience about learning disabilities and training at home with a supervision of a person without specific training, as parents or teachers.

The most part of the children who have been treated may reach a "normal" performance in accuracy, conversely, it was not possible to obtain the same result in speed.

It was also evident that all children obtained an important improvement independently from the fact that dyslexia is often associated with other learning disabilities.

Finally, the results showed us that we can find many different individual responses to the different kinds of treatment and the type of response to the intervention does not depend on the severity of the disorder.

Tressoldi & Vio (2011) published a review of the studies related to the interventions of Italian subjects with developmental dyslexia up to 2010. In this paper they examined the results of 41 outcomes of treatment found in 17 studies. More precisely, they compared four different kinds of treatment, sublexical (e.g., Tressoldi et al., 2012), lexical (Judica et al., 2002), balance model (Lorusso et al., 2004; 2005; 2006) an neuropsychological (Benso, 2008; Mogentale, 2009) with respect efficacy, relative to the changes in reading performance after treatment and efficiency, obtained calculating the relation between efficacy and the numbers of hours of treatment.

They found that the four types of treatment seem to have the same efficacy in reading a text, while, the sublexical and neuropsychological treatments allow significantly higher improvement than the other ones, in reading words and nonwords. Differently, analyzing the results on the ground of efficiency, that is considering the improvement with respect to the number of hours of treatment, the results show how, in reading a text, better results can be obtained using the sublexical, the balance model and the lexical treatment, in spite of the wide variability in these last ones.

About reading list of words and non words, a clear superiority of sublexical treatment on all the other kinds of treatment was evident.

To sum up, at the present state of evidences, it is possible to suggest that the treatments based on a sublexical model result more efficient.

The aim of this work is to give a further proof of efficacy and efficiency in the treatment of reading disability of dyslexic children, through a sublexical method implemented with the software Reading Trainer™ (RT).

Home rehabilitation using the RIDInet platform

From the research about the rehabilitation of developmental dyslexia, some important suggestions come out for an effective intervention. Among these, it is clear that treatment must have a minimum of frequency, that is done daily and cyclically, has to be individualized (set on the needs of a single patient) and systematic.

A daily treatment at the psychologist or speech therapist consulting room is not always possible, both for who is in charge of the treatment and for his parents.

Home treatment through a software is a way to bypass this problem and to allow public and private professionals to extend rehabilitation to a bigger numbers of young patients.

The "Cooperativa Sociale Anastasis" has developed RIDInet, an internet platform that allows the patient to practice every day, in any moment of the day and allow the clinical supervisor to check the results in real time and changing the parameters of the training exercises adapting them to the results obtained by the patient.

The system is online and allows creating an individualized treatment that can be modified at any time by the clinical supervisor who can be connected with the patient through a dedicated chat.

The software, thought also to reduce the frequency of the visits at the supervisor's site, allows a continuous supervision of the work made at home and stimulates a positive reaction of the patient.

This model of treatment can increase the number of patients that can be manage at the same time, reducing waiting times for the beginning of treatment.

This "mixed" model of rehabilitation, taken both at the professional site and at home, show many advantages and is more satisfactory both for patients and professionals.

RT is designed taking in account the dual-route developmental reading model (Coltheart, 1993; Frith, 1985), making possible speeding up the correspondences between graphemes and phonemes and automating the naming of sublessical units (syllable and morpheme) and complete words.

RT comprises some options devised to facilitate the sublessical and lexical processes (Spinelli, 2005) and the visual and visuo-spatial aspects involved in reading (Franceschini, 2012; Zorzi, 2012), for example selecting the reading units (letters, syllables, morphemes and words), presenting each of them alone or within sentences or texts; selecting the way in which the reading units are presented (self-paced or timed); the distance and the size of the graphemes, the space between the lines and the ways on how to underline the reading units.

METHOD

Participants

Thirty-four children with a diagnosis of developmental dyslexia according to criteria of the Italian "Consensus Conference" on learning disabilities (CCDSA, 2010) were included in this study.

Their disorder was diagnosed by clinical psychologists working in public clinical child units of Veneto and Toscana regions.

They were included in this study because they completed a treatment with RT for at least 3 months or no more than 4 months (from 12 to 16 weeks, with an average of 13) and training 15 minutes a day at least 3 times a week (with an average of 60 minutes a week).

At the beginning of rehabilitation, these children were attending primary or secondary schools (two in 2nd grade, eight in 3rd grade, ten in 4th grade, 8 in the 5th grades of primary school; two in the 1st grade and four in the 2nd grade of secondary school).

Procedures

At the beginning and at the end of the intervention all participants were examined reading a passage from the *MT reading battery* (Cornoldi et al., 1998, 2011) and reading the lists of words and nonwords of the *DDE-2 battery* (Sartori, Job & Tressoldi, 2007). Their fluency was expressed in syllable/seconds and their accuracy expressed in number of errors.

Efficacy outcomes

As used in Stella et al. (2001), Tressoldi et al. (2001) and Tucci et al. (2013), efficacy of treatment was estimated calculating the difference in fluency expressed in syllables/second in reading a passage, lists of words and nonwords between the beginning and the end of the intervention (gain scores).

These differences were compared with the change expected without treatment.

Efficiency outcomes

As used in Allamandri et al. (2007), Tressoldi & Vio (2011) and Tressoldi et al. (2012), efficiency was estimated calculating the number of syllables per second gained per hour of treatment.

RESULTS

Efficacy of fluency is presented in Figure 1 compared with the gain expected without training estimated in .3 syll/sec per year for reading a passage and lists of words, and in .15 syll/sec. reading lists of nonwords (Tressoldi et al., 2001). In Table 1, we report the efficacy outcomes related to both the fluency and the accuracy and the percentages of participants who reached or exceeded the level expected without training.

The level of reading fluency to reach or exceed estimated after 3.5 months of treatment, is equivalent to .10 syllables per second in reading a passage or lists of words and equivalent to .05 syll/sec in reading lists of nonwords (Appendix).

In Table 2, we compare the observed in this study compared with former studies (Allemandri et al., 2007; Tressoldi et al., 2012). It is interesting to observe that they are substantially similar.

In Figure 2, we report the measure of efficiency expressed in gains of syll/sec per 100 hours of training (to facilitate the comprehension).

DISCUSSION

With a training of a few hours a month we have observed clinically significant changes. Training at home save time for patients and their families they can use in other ways.

The most part of participants have reached a normal accuracy in reading and have improved their fluency more than expected without training. Our data confirm that the grade attended by the dyslexic children did not influence the efficacy outcome, giving further support to the evidence that it is possible to improve reading during the whole period of primary and secondary school.

In spite of the good results in efficacy and efficiency registered after the treatment, some questions remains. For example:

1) Do the observed improvement last and may continue in time?
2) Which results can we obtain repeating more times the cycle of treatment?

Figure 1 – Gain in reading fluency compared to the expected change without training

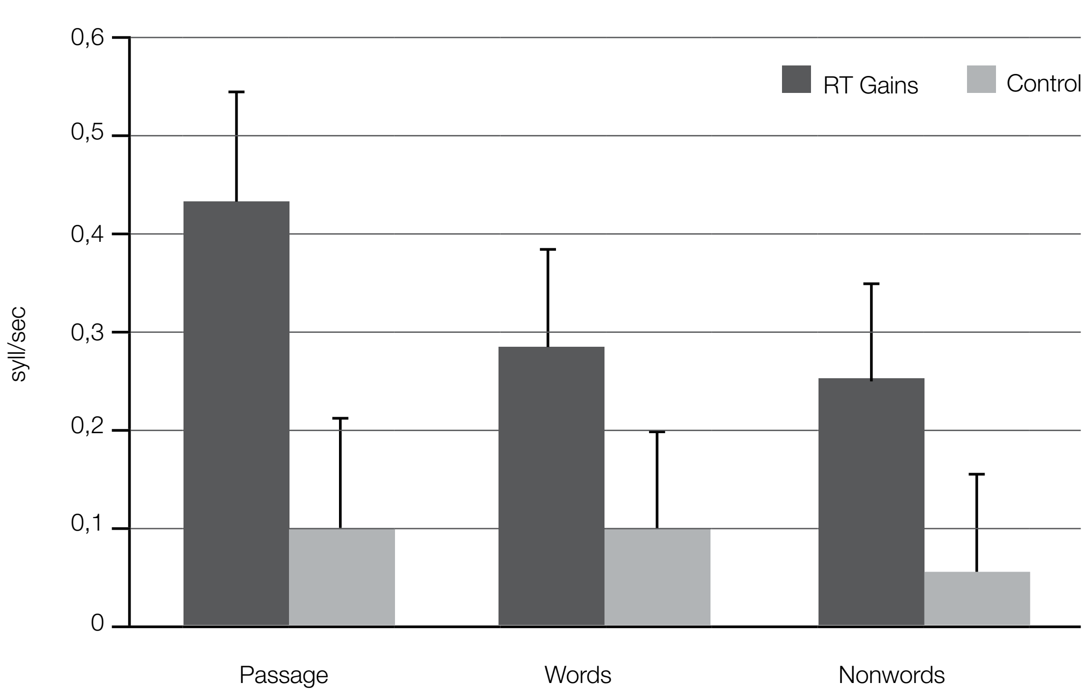


Table 1 – Improvements (gain scores) in the fluency and accuracy of reading and percentage of participants who reached or exceeded the level expected without treatment in fluency and the normalization in accuracy

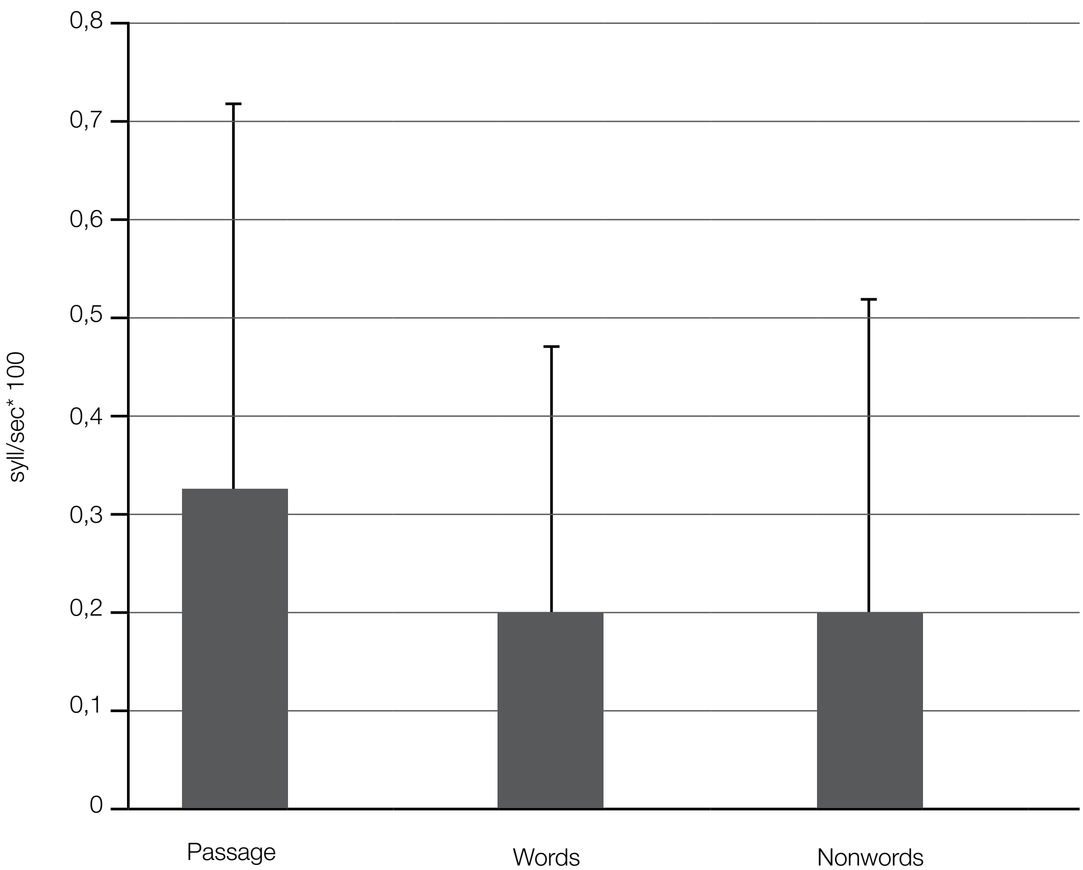
	Reading Tasks		
	Passage Mean (SD)	Words Mean (SD)	Nonwords Mean (SD)
Fluency	.43 (.34)	.28 (.29)	.25 (.32)
	29/34 (85%)	27/34 (79%)	27/34 (79%)
Accuracy	1.26 (4.42)	2.85 (5.44)	1.91 (5.71)
	33/34 (97%)	26/34 (76%)	26/34 (76%)

Table 2 – Comparison of efficacy between treatment outcomes observed in this study compared to former studies

		Efficacy (Gain scores)			
		Passage Mean (SD)	**Words Mean (SD)**	**Nonwords Mean (SD)**	**Hours of training**
Reading Trainer		.43 (.34)	.28 (.29)	.25 (.32)	14.07 (4.98)
Allamandri, 2007		.47 (.23)	.39 (.2)	.22 (.10)	19.4 (9.8)
Tressoldi, 2012	Home 1	.36 (.31)	.29 (.25)	.13 (.20)	5 (2.8)
	Home 2	.52 (.30)	.37 (.29)	.23 (.24)	23.4 (13.2)

If repeating the cycle of treatment more than once, we could obtain continuous improvement in the fluency and accuracy as that observed after only three months of training, it could be possible to reach a level of fluency sufficient to achieve a complete autonomy in reading so to concentrate the efforts only on how to improve the reading comprehension and the study skills. Furthermore we think that a better description of the different abilities involved in reading (phonology, selective visual attention, crowding, automatic RAN, etc.) may give us the possibility to setting better the RT parameters tailoring them to each individual characteristics so to achieve a greater likelihood of efficacy and efficiency.

Figure 2 – Mean and standard deviation of the efficiency expressed in gains of syll/sec per 100 hours of training.



References

ALLAMANDRI, V., BRENBATI, F., DONINI, R., IOZZINO, R., RIPAMONTI, I.R., VIO, C. et al. (2007). Trattamento della dislessia evolutiva: Un confronto multicentrico di efficacia ed efficienza. *Dislessia, 4* (2), 143-162.

BENSO, F., BERRIOLO, S., MARINELLI, M., GUIDA, P., CONTI, G. & FRANCESCANGELI, E. (2008). Stimolazione integrata dei sistemi specifici per la lettura e delle risorse attentive dedicate e del sistema attentivo supervisore. *Dislessia, 5* (2), 167-181.

CORNOLDI, C., COLPO, M. & GRUPPO, M.T. (1998, 2011). *La valutazione oggettiva della lettura*. Firenze: Giunti O.S. Organizzazioni Speciali.

COLTHEART, M., CURTIS, B., ATKINS, P. & HALLER, M. (1993). Model of Reading Aloud: Doul-Route and Parallel-Distributed-Processing Approaches. *Psychological Review, 100* (4), 589-608.

CONSENSUS CONFERENCE (2010). *Sistema Nazionale Linee Guida*. Roma: Istituto Superiore di Sanità.

FACOETTI, A, TRUSSARDI, A.N., RUFFINO, M., LORUSSO, M.L., CATTANEO, C., GALLI, R., MOLTENI, M. & ZORZI, M. (2010). Multisensory spatial attention deficits are predictive of phonological decoding skills in developmental dyslexia. *Journal of Cognitive Neuroscience, 22*, 1011-1025.

FRANCESCHINI, S., GORI, S., RUFFINO, M., PEDROLLI, K. & FACOETTI, A. (2012). A causal link between visual spatial attention and reading acquisition. *Current Biology, 22*, 814-819.

FRANCESCHINI, S., GORI, S., RUFFINO, M., VIOLA, S., MOLTENI, M. & FACOETTI, A. (2013). Action video games make dyslexic children read better. *Current Biology, 23*, 462-466.

FRITH, U. (1985). Beneath the surface of developmental dyslexia. In K. Patterson, M. Coltheart & J. Marshall, *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading*. London: Erlbaum.

JUDICA, A., DE LUCA, M., SPINELLI, D. & ZOCCOLOTTI, P. (2002), Training of developmental surface dyslexia improves reading performance and shortens eye fixation duration in reading. *Neuropsychological Rehabilitation, 12* (3), 177-198.

LORUSSO, M.L. & CATTANEO, C. (2007). Stimolazione emisfero-specifica secondo il metodo Bakker per il trattamento della dislessia evolutiva: Risultati e followup. *Saggi, 2*, 41-52.

LORUSSO, M.L., FACOETTI, A. & MOLTENI, M. (2004). Hemispheric, attentional and processing speed factors in the treatment of developmental dyslexia. *Brain and Cognition, 55*, 341-348.

LORUSSO, M.L., FACOETTI, A., TORALDO, A. & MOLTENI, M. (2005). Tachistoscopic Treatment of Dyslexia Changes the Distribution of Visual-Spatial Attention. *Brain and Cognition, 57*, 135-142.

LORUSSO,M.L., FACOETTI A., PAGANONI, P., PEZZANI, M. & MOLTENI, M. (2006). Effects of Visual Hemisphere-specific Stimulation versus Reading-focused Training in dyslexic children. *Neuropsychological Rehabilitation, 2*, 194-212.

MOGENTALE, M. & CHIESA, C. (2009). Esperienza di un trattamento combinato neuropsicologico sublessicale per la dislessia evolutiva. *Dislessia, 6* (2), 239-267.

SARTORI, G., JOB, R. & TRESSOLDI, P.E. (2007). *DDE-2 Batteria per la valutazione della dislessia e della disortografia evolutiva*. Firenze: Giunti O.S. Organizzazioni Speciali.

SPINELLI, D., DE LUCA, M., DI FILIPPO G., MANCINO M., MARTELLI M. & ZOCCOLOTTI, P. (2005). Lengh effect in word naming latencies: Tole of reading experience and reading deficit. *Developmental Neuropsychology, 27*, 217-235.

STELLA, G., FAGGELLA, M. & TRESSOLDI, P.E. (2001). La dislessia evolutiva lungo l'arco della scolarità obbligatoria. *Psichiatria dell'Infanzia e della Adolescenza, 68*, 27-41.

TRESSOLDI, P.E., BRENBATI, F., DONINI, R., IOZZINO R. & VIO, C. (2012). Treatment of Dyslexia in a Regular Ortography: Efficacy and Efficiency (Cost-Effectiveness) Comparison Between Home vs Clinical-Based Treatments. *European Journal of Psychology, 8* (3), 375-390.

TRESSOLDI, P.E., LONCIARI, I. & VIO, C. (2000). Results of the treatment of specific developmental reading disorder, based on the single and dual-route models. *Journal of Learning Disabilities, 33* (3), 278-285.

TRESSOLDI, P.E., STELLA, G. & FAGGELLA, M. (2001). The development of reading speed in Italians with dyslexia: A longitudinal study. *Journal of Learning Disabilities, 34*, 67-78.

TRESSOLDI, P.E. & VIO, C. (2011). Studi italiani sul trattamento della dislessia evolutiva: Una sintesi quantitativa. *Dislessia, 8* (2), 163-172.

TRESSOLDI, P.E., VIO, C., LORUSSO, M.L., FACOETTI, A. & IOZZINO, R. (2003). Confronto di efficacia ed efficienza tra trattamenti per il miglioramento della lettura in soggetti dislessici. *Psicologia Clinica dello Sviluppo, 7* (3), 481-493.

TUCCI, R., SAVOIA, V., MERELLA, A. & TRESSOLDI, P.E. (2013). La dislessia evolutiva lungo l'arco della scolarità obbligatoria: Una replica dello studio di Stella et al. del 2001. *Dislessia, 10* (3), 281-294.

ZORZI, M., BARBIERO, C., FACOETTI, A., LONCIARI, I., CARROZZI, M., MONTICO, M. & ZIEGLER, J.C. (2012). Extra-large letter spacing improves reading in dyslexia. *Proceedings of the National Academy of Sciences*, 109 (28), 11455-11459.