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Dyslexia and Champion L.I.R.M: Outcomes of a research study based on treatment of cross patterns

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Abstract

Greater efficiency in reading is now recognised as a key to fluent reading. In this approach, based on over 10 years of observations, rehabilitative treatments and targeted experimental interventions with children with severe deficits, we testify to the effectiveness of a motor and fluency treatment. Through intensive practice based on cross pattern activation aimed at enhancing general executive functions, and procedural / sequential motor skills, we find that reading and writing improve in terms of fluency. A clinical trial, conducted before and after the Champion LIRM intervention, on a sample of 20 dyslexic children between 7 and 13 showed an average improvement of 50/60 percentage in activation timing, accompanied with an improvement in reading. After intervention, both measures were accelerated towards the performance of control children, who provided normative data for the study, although the dyslexic children remained significantly slower.
Working in intensive cycles of 2 or 3 days, for a total of 15 hours, using a constant rhythm, applying motor and coordinated sequences, we promote the underlying processes of rapid activation, improving the automatization of neural circuits and exchanges between the hemispheres. This improvement and functional gains are also extended to include attention, general responsiveness, balance, and language.

Keywords: executive functions, automatization, cross patterns, motor coordination, reading, dyslexia

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Dyslexia

Dyslexia is traditionally diagnosed in terms of reading difficulties, with evidence of phonological difficulties in both reading and spelling (Snowling, 1981), and problems in rhyming (Bradley and Bryant, 1983) indicating phonological difficulties, as well as issues with memory (Baddeley, 2003). A review by the US National Reading Panel (2000) surveyed the many interventions that had attempted to improve the reading by addressing these phonological difficulties. The conclusions of this panel were that insufficient attention had been paid to aspects of fluency in learning to read, given that these interventions had significantly improved phonological processing, but not necessarily impacted on reading.

The importance of motor skills and the usefulness of motor skills interventions have long been highly controversial in the literature. However, research has confirmed that Dyslexia can also be characterized by a slowness and a disorder of executive processes (Varvara et al, 2014). This is particularly notable in terms of a sequential/ procedural disorder (based on scrolling in space and time). These aspects of performance can be observed in many forms of behavior (Crispiani, 2011; Fawcett, Nicolson and Dean, 1996), including reaction times (Nicolson and Fawcett, 1994; 2007; Nicolson, Fawcett and Dean, 2001; Stein 2001; Chiarenza, 1998, 2013, 2014).

In terms of behavior, in many cases, the dyslexic child is slow and poorly coordinated. This affects not only school performance (in terms of reading, writing and maths skills) but also many daily routines, based on difficulty in space – time organization, as many authors have observed from the beginning of the century (most notably Orton, 1929; 1937).

In particular, a dysfunctional, disorganized, discontinuous and ineffective planning can be observed in complex cognitive tasks. This condition leads to *disorganized performance* well beyond the difficulties in reading and writing. In fact, more and more frequently, the phenomenon has been associated with a disorder of executive functions related to all behaviour (Varvara et al., 2014). Underlying the functional and qualitative nature of dyslexia, as many authors have confirmed, lies an overlap between dyslexia and dyspraxia or "sequential dyspraxia" (Crispiani, 2011, Wolff, Cohen and Drake, 1984).

There is also a growing interest shared with neurophysiological analysis which investigates cerebral and sensory - motor processes that are related to executive performance. In this sense, some important theories have been derived from remarkable insights in this field that have been synthesized with the complexity of neurophysiological processes, rather than perceptual ones, in the following areas:

a. brain processing speed;
b. speed of information processing
c. speed of initiation processing (known as the 'incipit')
d. self-regulation and self-inhibition processes
e. fluidity between both hemispheres

With reference to the functional and qualitative nature of dyslexia, today this is widely attributed to executive functions, or in this case *executive dysfunction*. Current analysis is based on an increasing awareness at a neurophysiological level. This leads us to reconsider this phenomenon critically, both in terms of the definition and classification of dyslexia as a *learning disorder*, now more clearly proposed as an executive dysfunction – as a noted in the ICF diagnostic manual.

In this context, we present the theoretical frameworks of dyslexia and its related disorders, including the underlying dynamics and multiple actions about *mental processing* from which emerge some important points, namely:

- interhemispheric connections electrical transmission from occipital lobe to frontal lobes

From this interpretation, it is clear that our brain works in synergy and in a continuous bilateral activation, particularly during higher cognitive performance, where speed of execution is an important variable. This is supported empirically, with more and more frequent sources in the literature. This allow us to propose two key indicators of dyslexia/dyspraxia, which belong to the human condition such as *slowness and disorder*

Slowness is defined in two key executive timings:

a. slowness to initiate an action (the 'incipit')
b. dysfluency in action in terms of *slowness and precipitation or acceleration.*

The disorder is expressed in a lack of coordination of actions in time and space.

In dyslexia, there is always poorly established lateral dominance (dyslaterality[1])

- inconsistent dominance (left handed but not consistent)
- disturbed lateral dominance
- lateral dominance with interference (from the other limb)
- lateral dominance with mirrored tendencies (in clockwise closure, rotator patterns, reversal, and direction from right to left)
- lateral dominance with a physiological delay

Lateral dominance and its functioning are a fundamental neurobiological plan to understand human behavior and all of our actions. (Geschwind and Galaburda, 1988, 2013).

Interhemispheric exchange, cross patterns and neurophysiological activation

In reading, as in writing, maths skills and other superior functions, the activation and correctness of performance is guaranteed by a neurophysiological and harmonic action plan which is executed in reciprocity, coordination and in *executive*

1. Cfr. P. Crispiani, Dislessia come disprassia sequenziale, cit., pp.

consistency. The entire cerebral system is involved, with particular engagement for neural circuits whose functionality requires:

- a correct electrical transmission
- efficient exchange between hemispheres
- executive consistency (fluidity)

These functions, working in a highly coordinated executive regime, are decisive in ensuring accurate human action in motor, perceptive, thought, language, and orientation performance. This must always be supported by a good conjunction between the hemispheric processes.

Some biological conditions such as callosotomia, commissurotomy, Gerstman[2] Syndrome, DID[3] *(Disconnessione interemisferica precoce o evolutiva*), can express disorders in exchanges between the hemispheres, so, these actions are involved in severe disorders or disability.

In some cases, a severe interhemispheric disconnection (DIE) is highlighted by wide and consistent dysfunctional consequences, with slowness a condition of the disorder which is always involved. According to various theoretical approaches, a similar but not so invasive and severe condition, is widely found in another qualitative and discontinuous condition, named *executive function* or *dyspraxia* (motor disorders, speech disorders, phonetic-phonological disorder, disorganization in space-time, disorders of coordination, memory disorders, etc.). This is recognised condition that makes many executive functions precarious and difficult, but which can be improved through educational treatment.

In any case *slowness* and *disorder* are the most prevalent expressions of the disorder, strongly expressed by *randomization*. This disordered condition (not *deficit)* relates to functions, in terms of the execution of skills (not the learning). This has been explored in different theoretical options, supported by many authors from various approaches:

- Cerebellar dysfunction and related follow-up functions, or procedural learning skills (Nicolson, Fawcett and Dean, 2001); speed of reaction (Nicolson and Fawcett, 1994)

2. Gerstmann (Syndrome) - neuro-sensorimotor syndrome due to left parietal area (probable injury of the left angular gyrus or sub-cortical structures left), involves, altered spatial insight, right-left disorientation, finger agnosia, dyslexia, dyscalculia, dysgraphia disturbance of body image, but the syndrome is often combined with other parietal symptoms. In children (Developmental Gerstmann Syndrome - SEG) easily connects with dysphasia, dyslexia and dyspraxia, Suresh and Sebastian (2000) found a correlation between dyscalculia and agnosia of the fingers of one hand and between dysgraphia and left-right disorientation. Cfr. P. Crispiani, Hermes 2016. professional scientific glossary, Junior-Spaggiari, Parma 2015.

3. DID - Disconnecting or early evolutionary interemispheric - Due to immaturity, injury or dysfunction of the corpus callosum, or cutting or to the faulty interhemispheric connections (commissurotomy, collosotomia, agenesis), or the interhemispheric exchange, it indicates a syndrome in which the two hemispheres are not interconnected in an optimal way and are therefore disturbed, it features late or absent bilateral exchange. Cfr. P. Crispiani, Hermes 2016. professional scientific glossary, cit.

- Magnocellular dysfunction to abnormal neuronal migration (Galaburda and Livingstone, 1993, Livingstone et al, 1993; 1994, Stein, 2001);

- Slowness in auditory processing (Tallal, 1984, Tallal et al, 1995) and rapid naming (Wolf, 2009)

- Problems in phonology (Snowling, 1981) and rhyming (Bradley and Bryant, 1983)

- Disorganization and related slow neurophysiological activation and execution of patterns of action (e.g. Stein and Walsh, 1997; Facoetti et al., 2003; 2010; Chiarenza and Stagi, 1998)

- Lateral dominance disorder (dys-laterality) with interference in relation to inter-hemispheric exchange and the organization of space and time (Orton,1929;1937, Crispiani, 2011)

A key concept here that links behavioural aspects of language with motor skills, is a disorder in rapid naming in dyslexia (Wolf, 2009) with slow speed of access to the lexicon identified in a range of tasks including picture naming. Interestingly, rapid naming is a compendium task involving the co-ordination of a number of contributory processes, including eye movements from left to right (scrolling across the page), and maintaining your place on the page, in addition to identifying the stimulus, and retrieving the name.

The speed deficits identified, even when literacy is not involved, highlight the importance of cognitive motor fluency in dyslexia.

Moreover, recent work from Goswami and colleagues (e.g. 2011) has identified a disorder in rhythmic processing in the skills in the speed and tempo underlying language development, again critically related to timing in the brain.

Putting these findings together with recent insights on the brain and dyslexia, deficits in automaticity (Nicolson and Fawcett, 1990) would impact on the construction of neural networks, for the co-ordination and execution of complex skills.

Recent research (Perrachione et al, 2016) has identified differences in the neurophysiological neural adaptation on children and adults with dyslexia in response to a range of stimuli, including faces and objects, in addition to their deficits in reading.

Combining the theoretical trends described above with our thirty years of experience of prevention, teaching and rehabilitative treatment of reading and writing, this analysis suggests some more significant functions for the efficient execution of intentional and coordinated performance, namely:

- inter hemispheric exchange;
- cross patterns;
- neurophysiological activation (know as the 'incipit')

The Champion L.I.R.M. training

The promptness, the efficiency, the consistency and the self-regulation of the activation of three selected aspects, constitute the *active principle* of the rehabilitative practices of our Practical-Theoretical *Cognitive Motor Training* (Crispiani, 2016a). The system includes actions and procedures conducted with high intensity and a wide use of praxic-motor functions (based on a published programme Activity Gym, 12 Books - ecological –dynamic approach-Champion LIRM, Hydro Accelerate Program, and Play Prassic Program).

Growing importance has been given to the mastery and efficient carrying out of cross patterns, that are identified as highly significant in the execution of praxis (Chiarenza and Njiokiktjien, 2008). Cross patterns are the expression of the proper functioning and the neurophysiological interactions between a range of brain regions for overall inter-hemispheric exchange. These include the frontal lobes, pre-central area, post-central somatosensory area, the supplementary motor area, the parietal lobes.

Cognitive–Motor-Training enhances the consistent and persistent coordination of the Cross System in the lower limbs, upper and among the arts, in general praxic performance, stressing their *(incipit) readiness or rapid activation*.

The general improvement of executive functions, in particular cross patterns, with an appropriate training program (cross patterns training), leads to considerable improvement in reading speed, because the training involves motor skills, general coordination, space-time organization and scrolling from left right. This is the essential target of Praxic-Motor Theory (TPM) of dyslexia, and the special training known as CHAMPION L.I.R.M. *(Reading Intensive Speed Motor*), whose central axis involves fluent and versatile functionalization of neuro-cognitive-motor patterns, including Cross Patterns. In other words, greater efficiency of the cross system related to a functional conjunction in reading processes achieving two functional gains:

- readiness in reading (incipit)
- better fluidity in reading

Further information on the approach can be found in Crispiani & Palmieri 2014, 2015, 2016.

The Research

The research presented aims to establish whether or not this type of training can impact on reading fluency, following an earlier study (Palmieri and Crispiani, 2015). In many ways, it would hardly be surprising if an intensive motor skills treatment of this sort did not improve the targeted skills, i.e. motor co-ordination and speed. However, the primary aim of intervention with dyslexia has typically focused on improving reading skills. It is much more difficult to affect a transfer from the trained skills to reading. It should be noted that accuracy was not recorded here, and no doubt some trade-off between speed and accuracy would be expected.

The findings confirm the hypothesis of a high correlation between praxic-motor function and reading processes, taking as privileged indicators the *'incipit'*, - readiness in the execution of cross patterns and speed in reading.
There is clear evidence of improvement in some essential executive values, with particular reference to incipit and speed. This testifies to the effectiveness of Champion L.I.R.M. (Reading Intensive Speed Motor), a professional practice, based on motor and cognitive skills, as a part of the Cognitive Motor Training based on the Crispiani Method.

The Research Sample

The clinical trial was conducted before and after frequent Champion LIRM intervention, on a sample of 20 dyslexic children between 7 and 13, and on an equivalent control group. All dyslexic subjects also completed a complete functional assessment by Psychological and Pedagogical Center Victor Macerata, showing a picture of a syndrome of severe dyslexia/dyspraxia, affected by:

- General dyspraxia;
- Clumsiness (difficulty in rapid motor patterns and cross patterns, synesthesia, self-regulation);
- Hesitation in starting (incipit) both in praxic-motor coordination and linguistic expression;
- General lack of fluency in executive function also with alternating slowness and speed, disorder in automatic procedures;
- general lack of co-ordination;
- Disorganization of space and time;
- Poorly defined lateral dominance (dys- laterality),
- Slowness and lack of fluency in writing, with interruptions, inversions, cognitive loss, and tiredness;
- Slow and uneven writing, grapho-motor disorders, missed closures, graphic slips, interruptions (disconnected letters), dysorthography;
- Uncertain Maths skills in relation to writing long numbers, queuing, rapid movement in the line of numbers, oral calculation, reading comprehension problems, etc.

Reading was diagnosed for this study based on speed of reading connected texts.

The Intervention

The Champion LIRM system outlined above was undertaken over 15 hours spread over 3 days in an intensive intervention programme. The pre-tests were undertaken at the start of day 1, and the post-tests at the end of day 3. Three types of tests were undertaken, firstly in phase 1, measuring the 'incipit' or initiation of the motor task (cross patterning) for each participant. Secondly, considering the impact of a dual task designed to challenge automaticity in motor skills, by increasing the complexity of the motor skills task to include not only cross patterns but also rhythmic walking. In the 3rd phase, the speed of reading was assessed in terms of the time required to read 2 texts matched for length and difficulty.

The Process

The research was conducted in three phases in the period from January to July 2016

Test A - detection of speed in activation (incipit) of motor practices of cross patterns; in 2 conditions

Test A consists of individual tests, based on the execution of cross patterns and in its time measurement, and the activation time (incipit) to:

1. Cross patterns in the upper limbs;
2. Cross patterns in the upper limbs contemporary with basal motor skills (walking on spot, or forward and backward)

The format for this evaluation of the impact of cross patterning training is based on the teacher modelling the pattern and the child joining in once they have identified the pattern to copy.

Test B - reading speed detection

Methodology

Clinical Trial to detect Rapid Activation (Incipit)

Test A
Cross Patterns are described in Table 1.

Table 1: Test A—Cross Patterns

Exercise	**Cross Patterns (1)**	**Cross Patterns (2)**
Description	Execution of cross patterns with upper limbs on the chest and face . Difficulty: single task (Execution of a task).	Execution of cross patterns of upper limbs combined with base motor skill (walking in place or walking back and forth). Difficulty: *dual tasks* (execution of a dual tasks)
Execution Modality	The therapist standing in front of the child executes the cross pattern (e.g. Cross your arms at chest or face quickly). The child joins in and repeats the exercise	The therapist stands in front of the child and executes the cross pattern (Cross your arms at chest or face quickly) at the same time walking in place or walking back and forth). The child joins in and repeats the exercise
Start	The time is calculated from the start of the therapist, after showing the proof. (Modelling).	The time is calculated from the start of the therapist, after showing the proof. (Modelling).

Test B

Test B consists of reading texts appropriately selected by length (equal beats) and difficulty with an index (0.05) named Index of difficulty of the text (IDT). The index is the ratio between the number of long words (four syllable or more) and the total number of words. The child reads a new reading text (IDT) of 0.05. aimed at speed, obtainable from the time taken to read a new piece of the same length (bars and spaces) and the same index. This activity is not in conjunction with motor skills but after cross motor pattern training.

Results

The results were tabulated and a series of statistical analyses were undertaken

Phase one (before):

Test A - detection of the activation speed (incipit) of cross patterns in the execution of one task before and after the special treatment Champion LIRM for 15 hours in three days.

The chart shows the slowness in the incipit (start) in the group of dyslexics in the execution of a cross pattern (one task: cross patterns in the upper limbs on his chest and face.) compared to the control group.

The dyslexic takes an average of 2s 15ms in starting compared to a non-dyslexic that initiates the cross pattern on average in 205 ms.

Table 2 Data for dyslexic group on speed of initiation of movement at pre-test and post-test compared with control data (seconds/ms)

One Task Dyslexic Group		Control Group
Dual Before	Dual After	Control Group
2s 400ms	700ms	210ms
2s 200ms	700ms	200ms
2s 400ms	700ms	260ms
2s 100ms	500ms	190ms
1s 900ms	700ms	260ms
2s 400ms	500ms	220ms
2s 300ms	400ms	200ms
1s 500ms	400ms	200ms
2s 200ms	500ms	150ms
1s 300ms	300ms	150ms
2s 700ms	600ms	170ms
2s 400ms	600ms	190ms
1s 900ms	600ms	220ms
2s 300ms	700ms	170ms
2s 500ms	600ms	200ms
2s 600ms	800ms	250sms
2s 200ms	500ms	250ms
1s 400ms	400ms	250ms
1s 800ms	500ms	210ms
2s 500ms	500ms	150ms
2s 260m	545ms	205ms
56.00%		

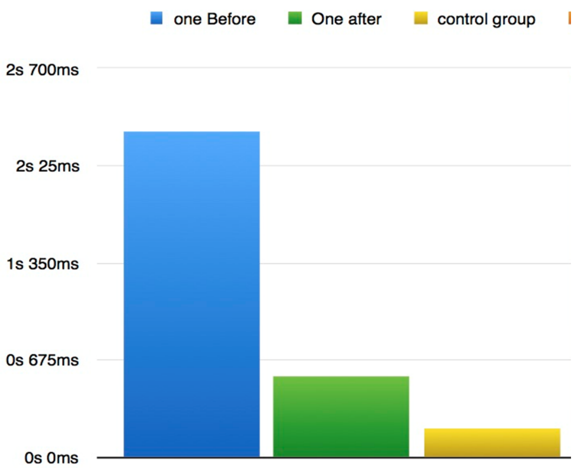

Figure 1. Bar chart of performance for incipit for pre-test and post-test compared with control baseline data

Overall, the dyslexic group is slower in starting (incipit, attack, initiation) and often appears hesitant, insecure and latent, not so accurate in the performance.

After special intensive treatment Champion LIRM applied for 15 hours in 3 days there is an appreciable improvement in the speed of activation (initiation) that, in fact, decreases to 560ms, equal to a percentage improvement of 74%.

A paired samples t test for pre-test and post-test performance, indicated a highly significant effect of the intervention, p=<.0001. A Cohen's effect size calculation of 3.9 indicated a large effect size for the intervention.

Table 3. Performance on motor dual task at pre-test and post-test compared with controls

Dual Task Dyslexic		**Control Group**
Dual Before	Dual After	Control
3s	700ms	210ms
2s 800ms	600ms	200ms
2s 300ms	400ms	260ms
2s 400ms	500ms	190ms
1s 900ms	400ms	260ms
3s 100ms	900ms	220ms
2s 300ms	500ms	200ms
2s 200ms	400ms	200ms
2s 500ms	500ms	150ms
2s 90ms	700ms	150ms
2s 700ms	600ms	170ms
2s 500ms	500ms	190ms
2s	400ms	190ms
2s 100ms	400ms	220ms
2s 500ms	500ms	170ms
2s 400ms	500ms	200ms
2s 200ms	400ms	250ms
2s 700ms	600ms	250ms
2s 600ms	600ms	210ms
3s	800ms	150ms
2s 667ms	545ms	205ms
54.50%		

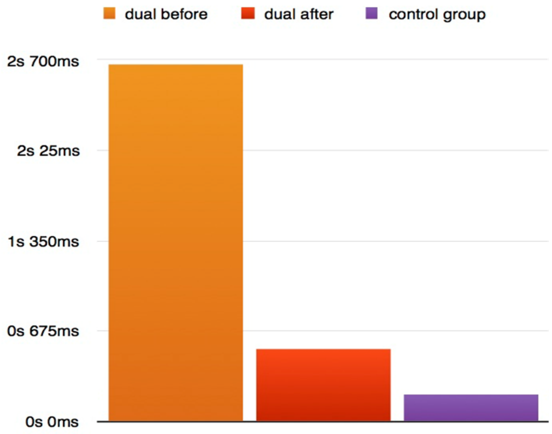

Figure 2 Bar chart comparing data from dyslexic group at pre-test and post-test with control baseline

Test B - detection of speed in activation (incipit) of motor practices of cross patterns in performing a dual task before and after the special intensive training Champion LIRM applied for 15 hours in three days.

The chart shows the slowness expressed by the dyslexic group in the performance of a dual task, consisting in the execution of cross patterns in the upper limbs combined with *basal motor skills* (walking in place or walking back and forth), compared to the same performance in the control group. The Dyslexic group activates the cross patterns with an average of 2s 51ms compared to the average of the control group which activates the cross pattern of a dual tasks in just 205ms. After the intervention, dyslexic performance improved by 46.5% to 0.545ms, but it should be noted that it

Table 4. Data on speed of reading before and after treatment for dyslexic group

Reading	
Dyslexic Before	Dyslexic After 3 days
3m 21s	2m 19s
4m 36s	2m 18s
2m 48s	2m
2m 43s	1m 8s
2m 32s	1m 24s
2m 33s	1m 4s
2m 25s	1m 4s
2m 2s	1m 8s
3m 20s	1m 20s
2m 30s	1m 10s
2m 0s	1m 23s
3m 40s	1m 25s
3m 25s	1m 2s
2m 40s	1m 28s
3m 10s	1m 4s
4m 32s	2m 36s
2m 34s	1m 7s
2m 57s	1m 5s
2m 45s	1m 2s
3m 5s	1m 15s
179s	85s
52.43%	

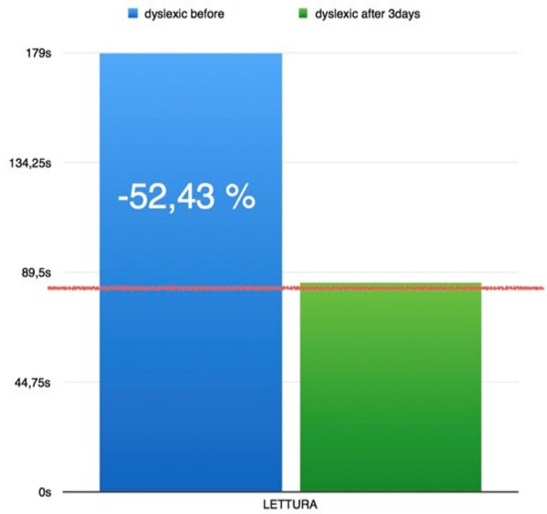

Figure 3. Difference in speed of reading texts before and after treatment

remains slower than the age matched controls.

A paired samples t test for pre-test and post-test performance, indicated a highly significant effect of the intervention, p=<.0001. A Cohen's effect size calculation of 5.7 indicated a large effect size for the intervention.

a. Test B – detection of reading speed before and after the treatment.

PHASE II: activation of special intensive training Champion LIRM applied for 15 hours in three days.

The graph shows the differences in speed in reading of texts of the same length and the same index of difficulty, before and

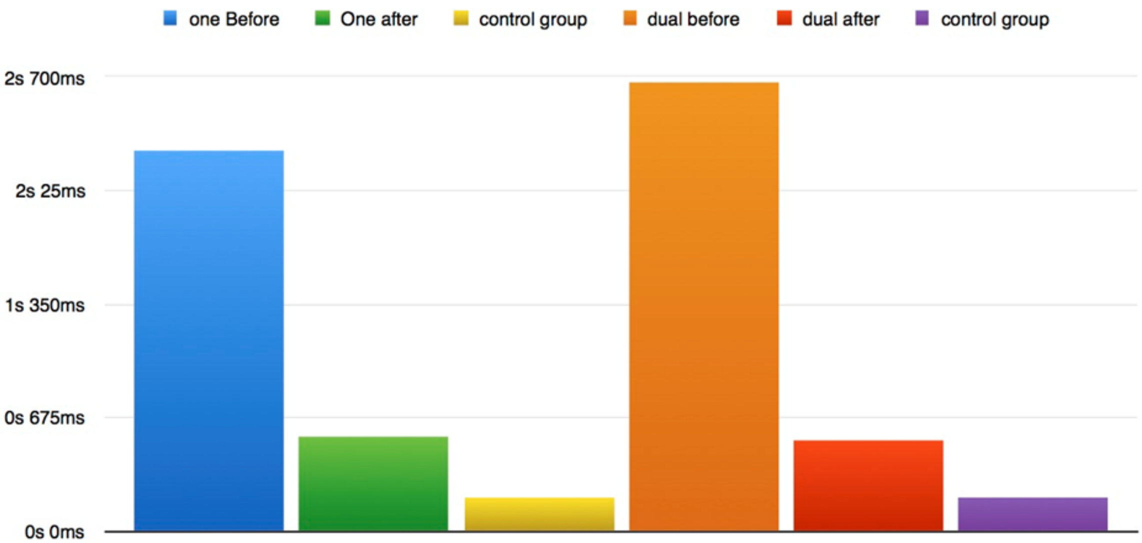

Figure 4. Summary of improvement from pre-test to post-test for single and dual task cross patterning in comparison with control baseline.

after treatment, detected as measurement of the reading time. In this case, qualitative and descriptive indicators of reading are detected in terms of fluidity (readiness incipit, perseverance, the right speed, shortage of breaks, shortages of errors, smoothness and consistency or reading, constant attention).

Further data combining the speed of reading (VEL) with qualitative reports (Fluency), allows us to derive an Individual Fluidity Indicator /(IFI) of a descriptive nature, not reported in this paper. To summarise, this IFI indicated improved performance on all parameters, with no significant loss of accuracy from informal observation.

With regard to the measurement obtained by VEL, the chart shows for each reader, starting from the left, the initial value and the post value after the special intensive treatment Champion LIRM. We note a significant reduction of the reading time equal to 52,43%, indicative of a significant improvement in speed.

A paired samples t test for pre-test and post-test performance, confirmed a highly significant effect of the intervention, $p=<.0001$. A Cohen's effect size calculation of 2.4 indicated a large effect size for the intervention.

In summary, the Intensive Treatment demonstrates high effectiveness in improving the speed of execution, see Figure 4.

Finally, a correlation of 0.75 was estimated between the motor and reading tasks.

Discussion

The results reported in the two test sections before and after the treatment, testify to some important consistencies in the impact of the intervention:

A consistent improvement is found after the intervention, in two senses:

a. increased activation of the start of motor practice – cross patterns (incipit);
b. reduction of the time necessary for reading texts of equal length and index of difficulty.

This research therefore supports a significant positive enhancement of performance in terms of speed, which is our term of reference here. Improvements were also noted informally in the fluidity of performance, amongst others.

The research documented here has placed in sequence two of the most important aspects of cognitive and learning performance: readiness in the *incipit* (initiation) in the execution of cross patterns and reading speed.

The Development of the therapeutic work applied on these two fronts confirms that, in response to a targeted and intensive therapeutic intervention, involving cognitive and motor skills (Champion LIRM), significant improvement was achieved in executive fluidity with a high correlation of 0.75 between motor and reading skills. This allows us to affirm and confirm that the two processes (reading processes and activation of increased efficiency of the cross system) are related and sensitive to the same rehabilitative treatment. Therefore, we can conclude that the reading process proceeds according to the same general function, readiness for activation, which we have defined in terms of the 'incipit'.

The level of this initial activation assumes a central importance in the determination of dyslexic's efficiency, especially in contemporary tasks where the dyslexic-dyspraxic tends to be even more slow, due to a difficulty in central neurophysiological processes, with particular involvement of interhemispheric exchange.

Overall, the dyslexic group is slower in starting (as indicated by the 'incipit') with performance of lower accuracy than controls. It is notable that this applied to 100% of the dyslexic participants, who all improved in all 3 parameters measured over the course of the intervention. Overall, significant improvements were found in all of the skills assessed, with no overlap with control performance, either before or after intervention, despite the significant improvements achieved.

In terms of the relative impact of the intervention, the effect sizes were striking, and related to the complexity of the task, so that the effect size for reading was lower than for the motor skill intervention itself. Nevertheless, an effect size of 0.2 is deemed small, 0.5 medium and 0.8 large for interventions of this type (Cohen **). It may be seen that an effect size of 2.4 is extremely large and suggests a higher impact than many studies in this field.

Limitations and directions for further research

The results here have indicated that all of the dyslexic participants have benefitted from the intensive support provided by the intervention. It is clear that all of these participants struggle with their confidence and self-esteem. No direct evaluation is reported here of the impact of self-esteem in these results, and it is likely that increased self-esteem and fluidity of movement enhances their confidence in word attack skills, known to be impaired in dyslexia. In future research, it would be useful to quantify these aspects with a questionnaire based on Likert scales that could address these issues. In many cases a characteristic reluctance to engage with reading for fear of failure can be noted in dyslexia, and any approach which potentially ameliorates this is to be commended.

It is also very clear that despite the very significant improvements the dyslexic participants have made in all their skills, they remain poor in comparison with the chronological age controls. Again, in future research, it would also be useful to compare baseline performance with children matched for speed of reading age. One might predict that these younger children would not show such striking slowness bin their initiation of movement, despite their lower reading ability.

In conclusion, 15 hours of intensive support using the Champion LIRM method of cross patterning in motor skill efficiency, had a significant impact on the speed of fluidity of reading in the severely affected dyslexic participants. Further research is needed using this approach in order to further validate these promising findings that can reinforce traditional intervention.

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