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Tesi di Laurea

On the oral comprehension of negative clauses in Italian by dyslexics

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Sommario

Introduzione

Il mio percorso di studi mi ha permesso di approfondire la mia conoscenza di vari disturbi del linguaggio come la sordità, l'afasia o il disturbo specifico del linguaggio. Prima del mio tirocinio formativo presso l'Università di Verona non mi ero mai occupata, nello specifico, della dislessia.

Questa esperienza è stata per me di fondamentale importanza perché mi ha permesso di approfondire la conoscenza su questo disturbo e di capirne meglio gli aspetti psicologici e relazionali. Avere, poi, la possibilità di parlare direttamente con ragazzi e ragazze dislessici delle loro vicissitudini scolastiche e universitarie mi ha arricchita molto anche a livello umano, facendomi comprendere come questa sia una vera e propria disabilità che, a differenza di altre, non si nota.

Ho deciso di organizzare la mia tesi in questo modo: nel primo capitolo si parlerà in generale della dislessia, delle sua manifestazioni sia per quanto riguarda la lettura o la scrittura sia per quanto riguarda argomenti grammaticali specifici come la comprensione e la produzione di frasi relative o passive. Ho messo poi brevemente a confronto la dislessia e il Disturbo Specifico del Linguaggio poiché molti studi si sono occupati di cercare una possibile relazione tra i due disturbi. Si passerà poi a descrivere brevemente le teorie che, negli anni, sono state elaborate per tentare di dare una spiegazione all'insorgere del problema.

Il secondo capitolo descrive, più nel dettaglio, il protocollo sperimentale utilizzato da Maria Vender nella sua tesi di Dottorato del 2011, a cui questa tesi e l'esperimento fanno riferimento. Vengono poi descritte nel dettaglio tutti gli studi e le teorie a supporto dei risultati.

Il terzo capitolo descrive nel dettaglio lo studio che ho proposto. Vi si troveranno le predizioni, una dettagliata descrizione dei materiali e del procedimento, nonché una

dettagliata esposizione dei risultati con l'analisi quantitativa e qualitativa dei dati a cui si aggiunge un'analisi statistica.

Questa tesi di laurea, inoltre, è stata resa accessibile alla lettura anche da parte di soggetti dislessici attraverso accorgimenti particolari quali la particolare impaginazione, il colore del carattere e il colore della carta su cui verrà stampata, grazie all'aiuto e all'esperienza della designer Maja Jovanovic.

Chapter 1 Dyslexia: an overview

Introduction

In this chapter I am going to overview the main significant aspects of dyslexia: the main theories that tried to give an exhaustive definition and explanation of the impairment, its manifestations and confronting it with a more severe disorder such as Specific Language Impairment.

1.2 Towards a definition of dyslexia

In modern society, written language represents one of the key strategies to communicate and to exchange a large amount of information. Given that nowadays society is strictly related to written language, being illiterate or showing poor skills in reading can easily lead to serious difficulties. While the majority of children learn quite easily to read with an appropriate education, a little percentage (about 3-10%) of children show significant difficulties in learning how to read.
Generally, with the term "reading" we identify the process with which people can understand the content or the subject of a written text, by means of complex phases regarding:

- *Identification of symbols;*
- *Knowledge of rules of conversion between symbols and sounds;*
- *Reconstruction of strings of sounds in lexical words;*
- *Understanding the meaning of single sentences and of the text.*

The first three phases of this process, defined as decoding, are crucial to the comprehension phase. Children who fail in these first three phases are often diagnosed with dyslexia.

Despite decades of research, there is no universally agreed definition of developmental dyslexia, presumably because the population of poor-readers is not homogeneous. Consider these following definitions of developmental dyslexia:

- *Developmental dyslexia is a brain-based type of learning disability that specifically impairs a person's ability to read. These individuals typically read at levels significantly lower than expected despite having normal intelligence. Although the disorder varies from person to person, common characteristics among people with dyslexia are difficulty with spelling, phonological processing (the manipulation of sounds), and/or rapid visual-verbal responding. In adults, dyslexia usually occurs after a brain injury or in the context of dementia. It can also be inherited in some families, and recent studies have identified a number of genes that may predispose an individual to developing dyslexia. (National Institute of Neurological Disorder[1]);*

- *Developmental dyslexia is a disorder in children who, despite conventional classroom experience, fail to attain the language skills of reading, writing and spelling commensurate with their intellectual abilities (World Federation of Neurology, 1968);[2]*

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[1] www.ninds.nih.gov/disorders/dyslexia

[2] www.medicinenet.com/dyslexia/article.htm

- *Developmental dyslexia is a specific impairment affecting the acquisition of reading and spelling skills, despite adequate intelligence, opportunity and social background, which occurs in absence of physical, neurological, emotional and socio-economical problems (Vellutino 1979);*

- *Developmental dyslexia, or specific reading disability, is defined as an unexpected, specific and persistent failure to acquire efficient reading skills, despite conventional instruction, adequate intelligence and socio-cultural opportunity (American Psychiatric Association, 1994);*

- *Dyslexia is evident when accurate and fluent word reading and/or spelling develops very incompletely or with great difficulty, despite appropriate learning opportunities – that is, learning opportunities which are effective for the great majority of children. (British Psychological Society, 1999).*

Although these definitions are much-quoted, they are far from giving a complete and detailed description of developmental dyslexia. So developmental dyslexia can be defined as a reading impairment referring to the process of interpretation of orthographical symbols, that uniquely concerns the transformation of symbols in sounds and is highlighted by a broken reading out with lots of different mistakes. The type of dyslexia that arises at the beginning of the reading acquisition process is defined as developmental dyslexia[3]. According to these definitions, those who display additional problems or conditions are excluded from the sample.

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[3] We should distinguish between developmental dyslexia and acquired dyslexia. Acquired dyslexia affects the reading skills of a subject who normally reads but unexpectedly begins to make mistakes or fails in word-recognition. Usually, these unexpected decoding difficulties are considered the consequence of some pathological event that damaged the cortical areas involved in the decoding process.

The WHO (World Health Organisation) set 5 conditions that should subsist in order to consider a reading disorder as developmental dyslexia:

- Normal Q.I. (≥85);
- The reading level must be significantly different from that of a child of the same age or school grade. In particular, if the reading level is evaluated with appropriate tests, it should be lower than the second standard deviation expected for the age or the school grade. For example, a fourth grade child who reads like a second grade, is considered dyslexic;
- The subject should not have any neurological or sensorial diseases that can validate as a direct consequence the difficulties in reading;
- The disorder should persist in spite of an adequate education and specific educational interventions;
- This may have consequences on schooling or in social activities in which reading and writing are required.

The picture that emerges is that what is crucial is the discrepancy between the reading skills and the general level of intelligence. This is a disease that significantly involves a specific domain of skills, leaving intact the operation of the overall intellectual level. In this sense, the principal essential criterion in order to diagnose dyslexia is the discrepancy between the skills in the specific domain and the general level of intelligence.

It is crucial to underline that reading disabilities cannot be considered neither the necessary nor the sufficient symptom of dyslexia. On the one side, in fact, there can be individuals who fail to be diagnosed as dyslexic although they display poor reading, whereas, on the other hand, it is not rare to meet people who should be diagnosed as

dyslexic because they manifest the wide range of impairments typical of dyslexia, but that aren't considered dyslexics since their reading and spelling abilities are relatively spared. This is the case, for instance, of children whose mother-tongue has a transparent orthography and whose reading difficulties may thus go unnoticed (Vender 2005).

Specifically, dyslexics perform very poorly when asked to read irregular words or non-words. Obviously, these difficulties are even more evident in languages with an 'opaque' orthography, as English, because in these languages phoneme-grapheme correspondence rules are less reliable than in transparent languages, such as Italian, where mappings between phonemes and graphemes are more regular and children have more chances to read properly both regular and irregular words (Piccoli 2008). This cross-linguistic discrepancy can be held responsible for the different percentages concerning the distribution of dyslexia that can be found across countries: in Italy, in fact, it is argued that dyslexia affects 3-4% of the population, whereas the percentage raises to reach 15-20% in the USA. Of course, this discrepancy does not imply that dyslexia is more widespread in one country than in another one; it simply reflects the fact that it is more easy to detect reading difficulties in children whose mother-tongue has an opaque orthography. On the contrary, the difficulties experienced by those children whose mother-tongue has a transparent orthography may go unnoticed (Piccoli 2008).

A second misunderstanding ascribes the difficulties in reading to psychological factors: in the clinical context the lack of information about the origin of dyslexia contributed to develop an approach that tends to identify psychological causes. Nowadays Italian clinical psychology still considers dyslexia as a disorder substantially emotional or relational, caused by the anxiety connected to the school performance or to the bad relationship between teacher and pupil or even to family problems (Stella 2004).

1.2.1 What is Dyslexia?

As argued in the previous sections dyslexia is a specific impairment affecting the acquisition of reading and spelling skills, despite adequate intelligence, opportunity and social background, which occurs in absence of physical, neurological, emotional and socio-economical problems. To determine whether a child is suffering from dyslexia his/her Q.I. must be measured and then, his/her reading abilities must be measures with standardised tests. Children who are 2 or more standard deviations below the average for what concerns reading correctness, speed and comprehension can be considered dyslexic (Vicari & Caselli 2002). Another criterion, mainly used in the United States, defines as developmental dyslexics children who show a delay in reading abilities higher than 2 years with respect to the class attended. For example, a child who attends the fifth class but can read as a second class pupils can be considered dyslexic.
Learning of written language needs a specific acquisition which begins between 4 and 5 years, to get to a completion, in the majority of the cases, in some months. According to many researchers, the reading learning process can begin when the child has acquired sufficient phonological abilities, that is phonological awareness, useful for reading acquisition (Zoccolotti et al. 2005).
According to the model proposed by Sartori (1984) and Coltheart et al. (1993), it is hypothesized that reading can pass through 3 ways:

- Phonological: from visual perception, moves through the conversion grapheme/phoneme and then through the phonemic buffer. It is the slowest because every phoneme is read singularly;

- Lexical way (non semantic): from visual perception it passes through orthographical lexic input, arrives to the phonological output lexicon and then to the phonemic buffer;
- Lexical way (semantic): goes from the visual perception to the phonemic buffer. It is used with well-known words.

Many models of reading acquisition have been proposed: one of these, the most quoted one proposed by Frith (1985), postulates the existence of 4 independent stages characterised by the acquisition of new procedures and of reinforcement of the abilities acquired in the previous stages:

- Logographic stage: in which he/she elaborates the salient properties of words;
- Alphabetic stage: the association between grapheme-phoneme is realised;
- Orthografic stage: children start with parallel elaborations and can read a whole word;
- Semantic stage: semantic lexical way is activated and reading becomes more fluid.

To sum up, the complete acquisition of the first 3 stages completes reading through the phonological way, while the achievement of the fourth stage allows children to correctly use the lexical way and rapidly reading known words without operating the conversion grapheme-phoneme (Denes 2009).
Many clinical classifications of developmental dyslexia have been proposed but one of the most used in Europe is Bakker's (1990) which distinguishes 3 types:

- Linguistic dyslexia: children with L dyslexia have normal reading speed, but make many mistakes carachterised by substitution or omission of words or letters. This represents the 30% of the cases. In this type a lacking functional development of the left cerebral hemisphere, with a correspondent impairment of the linguistic analysis during reading has been hypothesized;
- Perceptual dyslexia: children with P dyslexia can read very slowly but they do not commit many reading mistakes. This represents 30% of cases of dyslexia. It is believed that this type would depend upon an altered right hemisphere operation which determines an impairment a compromission in the visual analysis of letters and words;
- Mixed dyslexia: children affected by this type of dyslexia can read very slowly and make many omission errors and /or substitution of letters and words. This type of dyslexia affects 40% of children and it is believed that there should be a functional impairment of both hemispheres.

Another possible classification can be the following (Piccoli 2008):

- Phonological dyslexia: children read non-words with many difficulties. This can be a consequence of an arrest in the development of reading acquisition, in the transition from the alphabetic to the orthographic stage. The orthographic way is not compromised;
- Superficial dyslexia: children can easily read non-words while they show inefficiency in reading words with exception of pronounciation or with irregular accents. Reading is possible, though broken;
- Deep dyslexia: can be often observed and includes the typical symptoms of all the types mentioned above. The semantic way is compromised.

Together with dyslexia, there may be other issues as:

- Dysgraphia: is a specific writing disorder which affects the reproduction of alphanumeric signs and may be secondary to an incomplete lateralisation. It emerges only when children begin their writing customisation phase. Their writing is generally disorganised;
- Disorthography: is a specific writing disorder which affects the rules of conversion of spoken language into written language and cannot be held to the lack of experience or to sensorymotor deficits. Dysorthography is often accompanied by dysgraphia.
- Dyscalculia: is a disorder which affects performances of arithmetic calculations;
- Dyspraxia: is a disorder of coordination and movement and can also be related to language problems.

In spite of a large number of studies, causes of dyslexia are in large part still unknown. The majority of researchers unanimously connects dyslexia to neuropsycological deficits: to a reduced short-term verbal memory (working memory), or to the difficulties in the phonemic segmentation of words, or in the difficulty of finding words out (lexical access deficit) (Masutto, Bravar, Fabbro 1994).
Dyslexia, as dysphagia, affects with higher rates, males more tha females. Recently, an increasing attention has been given to the possible relationship between developmental dyslexia and specific language impairment (Bishop & Snowling 2004). The hypothesis of the study was that dyslexia would depend on a latent or pregressed language disorder. This hypothesis is corroborated by the verification that children with dyslexia show linguistic impairments that are typically found in developmental

dysphagias: for example articulatory disorders, phonemic and of lexical access. A substantial sample of children has been systematically subjected to batteries for assessment of language. Results seemed to confirm this hypothesis because the majority of children with dyslexia showed scores more than two standard deviations below the norm in one or more language tests. These results reveal that in the majority of cases dyslexia is a manifestation (a symptom) or the result of a pregressed language disorder. In recent literature, it has become common to use a less stringent criteria as the non verbal IQ within broadly normal limts and reading skills below the 25th and 30th percentile to distinguish the complex dyslexic children from children with specific language impairment (Bishop & Snowling 2004).

2. Manifestations of dyslexia

Developmental dyslexia is a complex and multifaceted disorder. Although they are the most evident and well-known symptoms of dyslexia, reading and spelling difficulties constitute only the tip of the iceberg of the more widespread impairments exhibited by dyslexic individuals. It has been ascertained, in fact, that their phonological and, more generally, linguistic competence is remarkably poor, and that they show great deficits in vocabulary and naming tasks (Vender 2011). Moreover, dyslexic subjects appear to be impaired in those tasks which require the automation of a skill and they frequently present motor and attention deficits.

2.1 Reading difficulties

Many studies about dyslexia concentrated on the poor development of reading skills which is one of the impairments that affect dyslexics who show a very slow, inaccurate and effortful reading but, more specifically, their difficulties seem to be caused by a basic impairment in the print decoding mechanism which causes disorders in word identification (Vellutino et al. 2004).
Reading errors typically concern a poor capacity to discriminate:

- similar graphemes which are differently oriented (e.g. “b” and “d”),
- similar graphemes which differ only for small details (e.g. “m” and “n”),
- graphemes that correspond to similar phonemes (e.g. “b” and “p”; “v” and “f”).

Reading errors do not only concern the discrimination of phonemes because dyslexics tend to substitute similar-looking, even if unrelated, words in place of the right ones (e.g. “play” for “pay” , “what” for “that”, but also “republic” for “publicity”).

Many studies (Baddeley et al. 1988, Johnston et al. 1987, Rack, Snowling & Olson 1992, Simos et al. 2000) repoted many difficulties in non-word reading corroborating the hypothesis of a phonological deficit as one of the main causes of dyslexia as we will discuss in the following sections. Other studies (Wimmer 1993, Wimmer and Goswami 1994, Seymour et al. 2003) highlighted that reading errors are more frequent in those languages that have an opaque orthographic system, like English rather than Italian. It had in fact been tested word and nonword reading in dyslexic children across different languages: significantly, results demonstrated that the accuracy rate was only 40% for English children at the end of Grade 1, whereas it was at a satisfactory level for children speaking languages with a more consistent orthography, such as German, Spanish and Italian.

Moreover, it has been found that reading speed rather than the accuracy is the most sensitive variable when comparing reading performance across languages. Ziegler et al. (2003), found that both German and English speaking dyslexics exhibited a marked speed deficit in comparison not only to chronological age-matched children but also to reading age-matched children, suggesting that dyslexia is characterized by a fundamental deficit that cannot be simply ascribed to a general developmental delay. Not surprisingly, dyslexics also showed that difficulties increase proportionally to the stimulus length a striking word-length effect. Analyzing the stimulus length in both words and nonwords, Ziegler et al. (2003) were able to estimate the processing costs required by each additional letter, showing that it increases dramatically in a linear fashion. The processing times needed to read long words, in fact, were up to 11 times greater for German dyslexics and up to 7 times for English dyslexics than for age-

matched controls. Ziegler et al. (2003) suggested that dyslexics' reading is extremely serial and letter-by-letter based, whereas it is much more parallel for control children. Summarizing, the main deficit exhibited by dyslexic children across countries appears to be poor reading fluency which is usually characterized by a slow and effortful decoding process. Moreover, dyslexics generally manifest great difficulties when asked to read nonwords and unfamiliar words and their impairment increases proportionally to the stimulus length. Finally, poor readers tend to commit more errors revealing that they are not obeying the orthographic-phonologic conversion rules and are often replacing similar-looking but unrelated words instead of the meant ones.

2.2 Spelling difficulties

Another of the symptoms generally manifested by dyslexics is the inability to acquire proper spelling skills which are strictly linked to reading acquisition as predicted by Ehri (1991, 1997) .

In comparison to reading, spelling is further complicated because, in languages characterized by phoneme-grapheme inconsistencies, as English, there is often more than one possibility to write a word in a phonologically acceptable way (e.g. "main" and "mane"). Caravolas et al. (2001), highlighted that spelling is affected by a variety of skills such as the familiarity with grapheme-phoneme correspondences, the ability to recognize the letters of the alphabet and the knowledge about orthography derived through reading. Attention, motor skills and visual memory, beyond phonological skills are also required for a proficient spelling.

Bourassa and Treiman (2003) tested both oral and written spelling performance of 30 dyslexic children (mean age 11 years and 1 month) and 30 spelling level matched younger children (mean age 7 years and 5 months) observing that dyslexic children

performed at the same level of younger children, producing the same kind of spelling errors. The misspellings produced by both groups of children were generally reasonable and linguistically motivated, including the omission of the second consonant in a complex cluster ("trip" spelled as "tip"), the omission of double consonants (e.g. "dinner" as "diner"), the confusion of graphemes corresponding to similar phonemes (e.g. "tomato" spelled as "tomado") and irregular spellings (e.g. "packed" as "packt"). Significantly, although dyslexic children were on average more than 3 and a half years older than control children, they produced the same kind of errors, so it was far impossible to distinguish between the two groups.

Interestingly, then, Bourassa and Treiman found that both groups of children tended to represent words better than nonwords, suggesting that they were using orthographic strategies to retrieve the visual shape of the proposed word. Obviously, in fact, it is not possible to employ the visual aspects to recover the spelling of an invented stimulus, whence the greatest difficulty found when nonwords were tested. This finding can be interpreted within the framework of the Dual-Route Model[4], offering interesting parallelisms with reading. As observed in the previous section, dyslexic children appear to rely more heavily on the lexical route for reading, retrieving the phonological form of the word from the orthographic input lexicon, which stores the spoken forms of familiar words. Given that dyslexics are more impaired with the spelling of nonwords, it seems plausible to assume that they adopt a similar strategy, recovering the visual form of the words from a phonological input lexicon, corresponding to the orthographic input lexicon, which is linked to an orthographic output lexicon, and storing the written forms

[4] The Dual Route Model is a theory of reading aloud elaborated by Coltheart (1985) and suggests two separate mechanisms, or cognitive routes, involved in reading aloud with outputs of both mechanisms contributing to the pronunciation of a written stimulus. Accoring to this theory, there are two processes through which one can read known words (lexical route) or non-words (sublexical route). This model can also account for developmental dyslexia in particular the phonological and the surface sub-types, which appear to affect both the mechanisms of reading. For more details see Coltheart (1985).

of words. Postulating the existence of a lexical route for spelling, similar to the lexical route of the Dual-Route Model, permits to explain why dyslexic children, as well as younger children who have just started acquiring literacy, are better at spelling familiar and frequent words, whereas they are particularly poor at spelling nonwords.
As predicted for reading, then, it seems that the sublexical route, which relies heavily on orthographic-phonological conversion rules, is particularly weak in dyslexic children (Coltheart 1985).

2.3 Phonological deficits

As stated before, it is now well known that phonological deficits are widespread between dyslexic as confirmed Ramus et al (2003) revealing that a large part of dyslexics show a phonological impairment.
The most distinctive phonological feature exhibited by dyslexics who showed a phonological impairment is very poor phonological awareness. Phonological awareness can be defined as a metalinguistic skill concerning the individual's conscious knowledge of the phonological structure of words, that is the precise sequence of sounds constitute words. As it is generally agreed by researchers, phonological awareness skills are necessary to succeed in reading because the decoding of words, in fact, involves linking graphemes to phonemes. Typical tasks testing phonological awareness require the subject to identify the initial, final or middle sound of words, to detect and produce words that rhyme, to segment words into syllables and sounds, to blend syllables and sounds into words, and to delete or substitute syllables or sounds in words.
Consistently, studies have demonstrated that children with poor phonological awareness are generally poor at reading, whereas children with a higher phonological awareness are more proficient readers; conversely, poor readers are significantly

impaired in phonological awareness tasks (Snowling 1995; Blachman, B. A. 1994, 1997, 2000; Rispens 2004).

Interesting insights come also from studies conducted on preschool children at familiar risk for dyslexia: in a longitudinal research Rispens (2004) reported that at-risk children performed more poorly than their peers on tasks testing phonological awareness and letter knowledge. After one year of reading instruction the results were re-examined and it appeared that the children who did not manifest normal reading progress were the ones who had shown the worst performance.

A strong correlation between phonological awareness and letter knowledge has been reported also by other researchers (Bowey 1994; Johnston et al. 1996; De Jong and Van der Leij 1999).

Moreover, remediation studies have shown that facilitating phonological awareness and orthographic-phonological conversion through direct instruction enhances performance in reading and spelling (Torgesen et al. 1999, 2001). In particular, Bus and Van Ijzendoorn (1999) conducted a meta analysis of experimental training studies and reported that improvement was higher when phonological awareness was trained in parallel with letter-sound correspondences.

A compelling body of evidence, indeed, confirms that dyslexics perform very poorly in phonological tasks and that their phonological awareness is significantly low, suggesting that their difficulties in analyzing the sound structure of words are responsible for their incapacity to acquire the systematic correspondences between orthography and phonology (Rack et al. 1992) .

Poor phonological awareness can also account for the non-word reading deficit typically detected in dyslexic individuals (see above section 2.1) because the ability to read nonsense pronounceable words, in fact, depends strongly on phonological processes and consequently on phonological awareness. Many research results support this idea

showing that nonwords reading is highly predictive of reading proficiency. In particular, Rack et al. (1992) reviewed 10 different studies involving a total of 428 dyslexics ranging from 8;5 years old to 13;2 years old and testing nonwords reading accuracy. Significantly, results show that dyslexics performed remarkably worse than reading-level matched normal readers, who ranged from 1;3 years to 5 years younger than them.

Furthermore, a number of researchers investigated the phonological coding in dyslexic children, administering speech perception and production tasks. Results showed that dyslexics perceived phonetic boundaries less sharply than normal readers (Manis et al. 1988; Adlard and Hazan 1997) and that they were worse than controls in the verbal repetition of both high and low frequency words and, especially, non-words (Brady et al. 1983, Elbro 1997).

In the experiments reviewed here phonological deficits have been typically assessed using metalinguistic tasks, relying basically on phonological awareness skills. A different perspective have been adopted by Desroches et al. (2006) who pursued a inedited approach, measuring phonological competence using the eyetracking tecnique. In their experiment, subjects were instructed to look at named items that were presented in a visual display, which contained the target item (e.g. *candle*), a cohort competitor which shared the initial syllable of the target items (e.g. *candy*) and/or a rhyme competitor (e.g. *sandal*). Results demonstrated that both dyslexics and age-matched control children showed lower recognition rates when a cohort competitor was present, suggesting that they were sensitive to this phonological overlap. Significantly, however, only control children showed slower fixation rates in presence of the rhyme distractor, whereas dyslexics did not, performing as fast as in the baseline condition, where no distractors were introduced, and thus demonstrating that they were not sensitive to the presence of rhyme competitors. This results seem to confirm that dyslexics are less

sensitive than controls in detecting rhyming relationships among words and, consequently, that they are less sensitive to phonological suprasegmental information. Moreover, Paulesu et al. (2001) performed an interesting study to test both reading and phonological competence in English, French and Italian adult dyslexics. As expected, they found that Italian subjects were less impaired than French and English subjects on reading test, due to the greater transparency of their orthographic system. However, Italians performed worse than controls and as poorly as English and French dyslexics in all phonological measures (i.e. word and nonword reading speed, digit naming, short-term memory and spoonerisms), giving further support to the idea that dyslexia is associated with a phonological deficit, which appears to be persistant across languages and orthographic systems. Moreover, differences between the three groups of dyslexics and the respective groups of controls have been confirmed with the PET technique, showing a significantly greater activation for controls in the left hemisphere, with the maximum peak in the middle temporal gyrus. No areas of significantly greater activation, instead, have been found in dyslexics in comparison to controls.

2.4 Vocabulary development and lexical retrieval

Vocabulary deficits and word-finding problems are often reported in the literature on dyslexia (Scarborough 1990, Wolf & Obregón 1992) and they are frequently referred to as early predictors of later reading achievements. In particular, dyslexic children's vocabulary has been found underdeveloped in comparison to that of age-matched typically developing children. Moreover, poor readers displayed a significant word-length effect (i.e. longer the word, poorer the performance) and a frequency effect (i.e. lower the frequency of the word, poorer the performance) (Wolf & Obregon 1992). Interestingly, vocabulary knowledge in preschool children has been also found predictive of early reading achievements. For example Scarborough (1990) found that at the age of 2:6 children who later developed reading disabilities, showed deficiencies in length, syntactic complexity and pronounciation accuracy of their speech production but their lexical or speech discrimination skills seemed spared. The difficulties continue as they grow up: at the age of 3 years old they begin to show deficiencies in vocabulary reception and object-naming abilities while at the age of 5 years old they show weaknesses in object-naming, phonemic awareness, and letter-sound knowledge.

The most interesting research on this topic concerns the performance shown by dyslexics and unaffected individuals in rapid naming tasks. The focus on this type deficits originally stemmed from the work implemented by Denckla (1972) and Denckla and Rudel (1976a, 1976b), who created the Rapid Automatized Naming (RAN) tests to measure serial speed naming, in which subjects are asked to name as quick as possible visually presented stimuli such as alphanumeric characters, colors, and drawings of simple objects.

This rapid naming tasks has been administered to dyslexics demonstrated that both children and adults are significantly slower than unaffected subjects on all RAN measures. In particular, Denkla and Rudel found that dyslexic children across age and

languages were slower at picture naming not only in comparison to age-matched control, but also to reading age-matched control.

An early poor performance in rapid naming tasks can also predict later reading difficulties, as firstly shown by Wolf, Bally and Morris (1986). In their longitudinal study, they investigated the development of word-retrieval speed and its relationship to reading in 83 impaired readers. Results revealed that impaired readers performed slower than normal readers on all naming measures across al years. Manis et al. (1997) in their study showed that dyslexic children have a perceptual deficit that may interfere with processing of phonological information, corroborating the hypothesis of a correlation between naming speed and reading performance.

Wolff et al. (1990) argued that naming deficits persist also in adolescence and adulthood and reported digits and letters naming deficits in adult dyslexics.

In an interesting study, Fawcett and Nicolson (1994) analyzed three groups of dyslexic children aged 8, 13 and 17 years old, comparing their performance to the performance shown by three groups of typically developing children matched for age and IQ, and a group of 10 years old children of children with mild learning difficulties (IQ between 70 and 90) matched for reading age with the 8 years old dyslexics. Subjects were asked to rapidly name objects, colors, digits and letters. Results showed that dyslexic children were significantly slower at naming colors, digit and letters in comparison to age-matched control children, whereas they performed as younger but reading age-matched controls. Remarkably, they showed a significantly poorer performance also in comparison to reading-age-matched controls when asked to rapidly name pictures. Specifically, 17-year-old dyslexics performed only at the level of 8-year-old controls in letters and pictures naming, suggesting that the naming deficits are persistent and very severe. The 10-year-old slow learners, instead, performed as 8-year-old dyslexics, compatibly with their reading age.

As the authors suggest, the longer latencies shown by dyslexics across age seem to reflect a less automatic or less efficient lexical access or an impaired lexical retrieval or assembly of the sequence of phonemes making up words.
Another interesting aspect to reflect on is the greater difficulty shown by dyslexics when they are asked to rapidly name pictures of simple objects, in comparison to colors and alphanumeric stimuli. Presumably, this can be due to the fact that there is a limited number of colors, digits and letters, whereas in the case of objects the number of possible alternatives increases radically. Dyslexics' slowness, then, seems then to increase proportionately to the number of possible responses, suggesting that the deficit affects the amount of processing required, more than the speed of reaction.

2.5 Grammatical deficits

Recently, many studies demonstrated that deficits in dyslexia are not confined to the domain of phonology, but they can also affect grammatical competence as well, influencing dyslexics' performance in tasks tapping morphology, syntax and semantics. Bishop (1991) corroborated this hypothesis, carrying out a series of researches confirmed the existence of a correlation between syntactic abilities and reading disabilities.
The correlation between syntactic or grammatical ability and reading proficiency was originally suggested by Fry, Johnson and Muehl (1970), who reported that poor readers produced significantly less complex constructions that their peers, as it was further confirmed by Muter and Snowling (1998) who found that grammatical competence in early childhood was predictive of reding achievements.

2.5.1 Dyslexia and the interpretation of relative clauses

The comprehension of relative clauses has been investigated in many studies revealing that poor readers have more difficulties than good readers (Mann et al. 1984, Bar-Shalom et al. 1993) and that their performance resembles that shown by younger children (Sheldon 1974).

Before starting with the descripstion of the difficulties of dyslexics with relative clauses, We can it is proper to distinguish foyur main types of relative clause:

- Subject-modifying-subject clauses (SO)

  The lion that hits the bear [*the lion*] rolls the ball.
- Subject-modifying-object clauses (SO)

  The bear that the lion hits [*the bear*] rolls the ball.
- Object-modifying-subject clauses (OS)

  The lion hugs the bear that [*the bear*] rolls the ball
- Object-modifying-object clauses (OO)

  The bear bites *the lion* that the ball hits [*the lion*]

The presence of a superficially missing noun phrase which is not phonetically realised is the syntactic feature characterising relative clauses. Considering the case of an Object-modifying-subject (OS), to understand it correctly the hearer must first recognise that there is a phonetically empty noun phrase in the subject position of the relative clause and then he/she must interpret it as coreferential with the overto object noun phrase the bear in the main clause. This computation is arguably quite difficult for young children as confirmes by acquisition studies showing that SS clauses are acquired before OO clauses, which are in turn acquired before SO and OS clauses (Sheldon 1974).

The same reasoning seems to be valid for dyslexic children who appear to have troubles with the interpretation of SO, OS and OO relative clauses as demonstrated by Mann et al. (1984) who tested poor and good readers' competence by means of an act-out task. To explain dyslexics' poor performance, the authors refer to the concept of an impaired working memory, arguing that their limited phonological memory can affect their language comprehension (this aspect will be discussed in detail in the following sections).

In a subsequent study, Smith et al. (1989) performed a slightly different experiment, analysing the same relative clauses but inseting them in a more felicitous contexts. The authors proposed two methodological changes to verify if the decreased load on working memory had an effect on dyslexics' performance. First, they reduced the number of NPs mentioned in the sentence from three to two, and secondly they satisfied the presupposition associated with relative clauses, which states that restrictive relative clauses are felicitous only when more than one object corresponding to the relativized element is present in the context. For instance, sentence in the example is not uttered felicitously when there is only one girl in the context:

The boy kissed the girl that was wearing a red dress

Relative clauses have been further tested by Bar-Shalom et al. (1993). In their experiment, again an act-out task, the authors adopted only one of the two methodological changes introduced in Stein and colleagues' study, reducing the number of animate NPs from three to two, but without satisfying the presupposition of the relative clause contained in the test sentence (i.e. there was only one character corresponding to the relativized NP). This choice was motivated by the need to determine which one of the two modifications was responsible for dyslexics' enhanced

performance reported in Smith et al.'s paper. They argued that dyslexics' difficulties with relative clauses are mainly due to pragmatic rather than to syntactic factors. As their peers, in fact, poor readers have intact competence of relative clauses, but manifest problems when the sentences are uttered out of an appropriate context. In particular, Bar-Shalom et al. propose that the absence of the extra character, which would satisfy the presupposition required by restrictive relative clauses, forces the subject to augment their mental model to accommodate the unsatisfied presupposition. This extra computation necessitates of additional working memory resources and it is therefore responsible for dyslexics' and young children's errors.
Bar-Shalom et al. (1993) tested also production, elicitating relative clauses to verify if dyslexics' problems were confined to comprehension or whether they extended to production. Results corroborated the results found by Mann et al. (1984) dyslexics were significantly worse than controls on SO, OS and OO relative clauses, indicating that reducing the number of NPs is not sufficient to eliminate poor readers' problems, which appear to be rather due to the pragmatic infelicity of the context of utterance.
It remains, however, unexplained why both poor readers and preschool children perform better with SS clauses and manifest the greatest difficulties with object-extracted relative clauses, i.e. OS and OO clauses. This problem is successfully handled by Gibson (1991, 1998), who supports one of the most successful approaches to sentence comprehension, arguing that the online computation of an utterance involves the temporary storage of the partial information obtained with the comprehension process, in order to allow the human parser to compute the necessary linguistic dependencies between the elements in the sentence.

2.5.2 Dyslexia and the interpretation of passive sentences

The interpretation of passive sentences in dyslexic children was originally investigated by Stein et al. (1984) who reported that poor readers performed as well as good readers with both reversible and non-reversible passive sentences[5].

These results have been recently challenged by Reggiani (2010), who found that dyslexics are remarkably impaired in the interpretation of reversible non-actional passive sentences, performing at the same level of preschool children, four years younger than them. Reggiani observed that Stein et al. (1984) tested only long actional passives, which are interpreted without difficulties even by 3 years old children. Starting from this consideration, Reggiani included in his experimental protocol a picture selection task, with more complex passive sentences, divided in four conditions, as reported below with an example for each condition:

- Non-reversible passive sentences with actional verbs:
  "Winnie the Pooh is eaten by honey".
- Non-reversible passive sentences with non-actional verbs:
  "Donald Duck is heard by the alarm clock".
- Reversible passive sentences with actional verbs:
  "The girlfriend is kissed by Donald Duck".
- Reversible passive sentences with non-actional verbs:
  "Winnie the Pooh is seen by the bees".

---

[5] Reversible passive sentences are those constructions in which the agent and the patient can be switched maintaining a semantically plausible meaning. Conversely this exchange cannot take place with a non-reversible sentence, as shown in the examples below:

a) The girl is kissed by the boy.
b) The apple is eaten by the boy.

The sentence in a) is said to be reversible, since if the patient *the girl* is exchanged with the agent *the boy*, the sentence remains semantically plausible. The utterance in b), instead, is classified as non-reversible, since if the subject *the apple* is swithched with the agent *the boy*, the sentence does not make sense anymore.

The protocol was administered to a group of dyslexic children (mean age 9;7), a group of age-matched controls (mean age 9;7), a group of young controls (mean age 5;8) and a group of adults (mean age 35;8). The method used was a Truth Value Judgment Task: the subject was shown a picture portraying two characters performing some actions and then he/she was asked to evaluate a target sentence pronounced by a clumsy puppet to determine what happened in the story.

Results showed that age-matched controls performed adultlike in all conditions, whereas dyslexic children were significantly impaired in those tasks involving reversible non-actional passives as the one reported in (15d). Specifically, dyslexics subjects, as well as younger children, accepted a sentence like (15d) as a correct description of a picture portraying Winnie the Pooh that sees, without being seen, some bees.

This finding, discarding the hypothesis that dyslexics do not manifest problems with the interpretation of passives proposed by Stein et al., suggests that dyslexic children suffer instead from the so-called Maratsos Effect that accounts for the greatest difficulty met by young children with passives involving psychological non-actional verbs in comparison to actional verbs.

Different theories have been developed to account for this phenomenon even if the most plausible explanation, supported also by Reggiani (2010), argues that the Maratsos Effect is due to a processing deficit: due to their limited processing resources, children are not able to handle both psychological verbs and the non-canonical word order typical of passive sentences. The interaction of these two factors imposes too high processing costs and it is thus responsible for the failure found in the interpretation of reversible non-actional passives.

To summarize, Reggiani (2010) demonstrated that dyslexic children are impaired in the comprehension of passive sentences and that they display the Maratsos Effect at an age at which they should have mastered an adultlike comprehension of passive sentences,

as shown by age-matched controls, suggesting that their difficulties are determined by a processing deficit.

2.5.3 Dyslexia and morphosyntactic agreement

Morphosyntactic impairments have been detected in dyslexic subjects by a number of studies as, for example, the research conducted by Joanisse and colleagues (2000), who administered on a large sample of 61 dyslexics (mean age 8;7), a group of chronological age-matched normal readers (mean age 8;5) and a group of reading age-matched controls (mean age 6;11), a test on inflectional morphology, in order to test their abilities to apply past tense agreement rules and plural rules to both familiar words and nonwords. Specifically, subjects were shown a picture portraying two or more of the same objects, and they were prompted to provide the plural of the noun. Both regular (e.g. fish>fishes) and irregular plurals (e.g. foot>feet) were tested; in the case of nonwords, subjects were presented with an invented noun corresponding to a fictitious creature. Similarly, they were asked to provide the past tens of regular verbs (e.g. bake>baked), irregular verbs (e.g. drive>drove) and nonsense verbs (filp>filped). Results showed that dyslexics performed remarkably worse than age-matched controls on both tasks, whereas their performance was slightly but not significantly worse than the performance of reading age-matched younger children.

The same findings is reported by Jiménez et al. (2004), who tested gender and number agreement in a group of reading disabled children (mean age 9;8), chronological age-matched controls (mean age 9;7) and younger reading age-matched controls (mean age 7;6). Participants were asked to complete truncated sentences with two alternatives differing in gender or in number. The authors tested also the ability to assign syntactic roles, presenting subjects with a picture and a series of sentences varying in that subject

and object roles were reversed, only one of which corresponded to the image. Finally, they focused on function words proposing two kinds of tests: in the first task, subjects were shown two pictures and a sentence and they were asked to decide which picture corresponded to the sentence. In order to accomplish this kind of task, they must be able to understand the meaning of the function word used in the sentence. In the second task, they had to complete a sentence with one out of two function words. Jiménez et al. (2004) found that children with reading disabilities had a very poor performance, committing more errors than chronological age-matched controls and even than reading age-matched control in all tasks.

A morphosyntactic impairment has been detected also by Rispens (2004), who tested morphosyntactic agreement in Dutch children by means of a grammaticality judgment task. Her experiment was performed on a group of dyslexic children (meanage 8;09) a group of chronological age-matched control (8;11) and a group of reading age-matched controls (mean age 7;01). Participants were presented with grammatical and ungrammatical sentences and were instructed to press a button with a smiling face for correct sentences and a button with a frowning face for incorrect sentences. Moreover, Rispens also tested spontaneous speech, elicited by a fixed set of questions about holidays, family, hobbies and so on.

Results revealed that dyslexic children always underperformed in comparison to both groups of control children in the grammaticality judgment task, failing to recognize agreement errors. Dyslexics displayed a poor behavior also in production, uttering an incorrect inflection in 17% of the instances, compared to the 99% correct performance of control children. Their errors comprised principally the omission of agreement markers and the substitution of the plural inflection with a singular inflection.

To summarize, the experiment performed by Joanisse et al. (2000), Jiménez et al. (2004) and Rispens (2004) reveal that dyslexic children's morphosyntactic competence is highly

impaired in comparison to both chronological age-matched and reading age-matched control children. Moreover, the significant difference found between dyslexics and reading age-matched controls shows that impaired children underperform also in comparison to younger children (around two years younger in the experiments discussed above). In addition, the poorer performance shown by dyslexics in comparison to younger controls confirms that their difficulties cannot be ascribed to their reading deficits.

3. Dyslexia or Specific Language Impairment (SLI)?

As stated above, there seems to be a strict relation between linguistic abilities and dyslexia. This is true also for children who suffer from Specific Language Impairment (SLI) because a high percentage of them (about 40-60%) of them also show reading problems (Catts, Hu, Larrivee & Swank 1994). Researchers unanimously observe that children with severe reading difficulties are at high risk of developing reading difficulties. This suggests that dyslexia and SLI may be related impairments.

3.1 General carachteristics of SLI

SLI is specifically an impairment in language acquisition that affects children with normal intelligence and hearing, without apparent neurological or psychological problems and without relevant social and economical difficulties (Fabbro 2000).
It has been calculated that more than the 5% of school children may show an SLI impairment and it is 3 or 4 times more frequent in boys than in girls. Many children affected show a left-hand preference and the majority of them (nearly 50%) has another relative (father, mother or siblings) with the same impairment. The causes of this weakness are still unclear though, recent studies associates part of the SLI to the presence of microscopic abnormalities diffused in the cerebral cortex maturation. Other research point out that some specific impairments are caused by generic deficits (Vargha-Khadem et al. 2005).
The language development in children affected by SLI is often damaged at all levels. Common carachteristics between all cases are:

- Language emerges later than the normal;

- Language can show distorted structures and remains at a lower level than the aga-expectancies;
- Children affected show impairments with flexive morphology.

There are also some differences concerning the extension of the impairment:

- Only some aspects of the flexive morphology are damaged;
- SLI can also affect some areas of the grammatical knowledge;
- The acquisition of words (verbs in particular) seems vulnerable;
- Light phonological deficits are observed;
- The impairment can be expressive or receptive

There are many theories that try to explain the SLI deficits. Many of these appear to be of great value but none of these seems to explain in a complete and exhaustive way the linguistics symptoms of SLI. Some of them appear to be too tight in their applicability because theories are inspired by observations in a specific language. For example, relying on SLI symptoms in German, Clahsen & Hansen (1993) formulated the Missing Agreement Hypothesis in which he proposed that the problem may consist in determining the structural relations of grammatical agreement. In particular, this deficit is determined by the incapability of establishing agreement relations with the subject. Moreover, this theory predicts that subjects with a diagnosis of SLI also have problems with subject-verb agreement and with finite auxiliaries. Cipriani, Bottari and Chilosi (1998) collected contrasting results with studies on Italian, a language with a rich system of morphological agreement, stating that the subject they tested with a longitudinal study do not seem to have any deficits in the processing of subject agreement relations. Clahsen with his Missing Agreement Hypothesis states that SLI does not exist in languages like Swedish or Afrikaans, that do not present subject-verb agreement. Actually, SLI in these languages does exist and the Missing Agreement

Hypothesis as other theories, are rather limited to explain this deficit as the Representational Deficit for dependency relations (RDDR) even if in its more recent formulation this theory has been renamed as Computational Complexity Hypothesis. This theory finds the cause of SLI in the syntactic computational system (Van der Lely 1998, Van der Lely & Battel 2003) and stems from Chomsky's Minimalist Program (1995) where long-distance dependencies need movement, defined as the attraction of uninterpretable features (as tense and gender) for the realisation of feature checking. This hypothesis supports the idea that the deficit responsible for grammatical errors in SLI lies in the movement and the prediction is that children with this deficit may have problems in comprehension and in the production of all elements that constitute syntactical dependencies.

According to other theories, children with SLI may have a limited capacity in the storage and processing of the information; the idea that we all have limited cognitive resources is shared by many models: Baddeley (1996), Bloom (1993), Bock & Levelt (1994), Just & Carpenter (1992). In situations in which a given task requires additional resources available, the elaboration or the mainteinance of the information in the memory are negatively affected and a little resources are available for the elaboration of other aspects.

To sum up, the main limitation of these theories is their failure in giving an adequate explanation of SLI as a deficit and to explain all patterns of errors and the production of correct forms.

In the academic research there have been much discussion about SLI in particular to understand if this impairment could be considered homogeneous, if difficulties could be predicted or if every child diagnosed with SLI is impaired in syntax. Friedmann &

Novogrodsky (2008) tried to identify several subtypes of SLI, since in many other studies it has been considered as an heterogeneous deficit which causes difficulties in various aspects of language: word finding, phonology, morphology, syntax, semantics and pragmatics (Bishop 2006, Conti-Ramsden & Botting 1999 2006, Clahsen 1989, Van der Lely 1996 1997, Rice, Wexler & Cleave 1995). Some researchers suggested that different children show different patterns, and that SLI can be further classified into subgroups according to the language component that is impaired (Bishop 2006, Friedmann & Novogrodsky 2007, Rapin & Allen 1983, Van der Lely 2005). Friedmann & Novogrodsky explored the possibility that a selective impairment of syntax and more specifically of syntactic movement cannot exist without an impairment in other cognitive abilities as, for example, lexical retrieval or phonological and pragmatic deficits. All children tested had a diagnosis of SLI but their pattern of performance differ greatly and this led them to the identification of:

- SySLI (Syntactic SLI) show a severe impairment in the comprehension of noncanonical sentences derived by Wh-movement incuding object relatives and referential object questions, and have difficulties producing objects relatives. A large part of the subjects tested showed good lexical and phonological abilities;
- LeSLI (Lexical SLI) show an impairment in lexical retrieval, but their syntactic abilities (and specifically their comprehension and production of sentences derived by syntactic movement) are intact;
- PhoSLI (Phonological SLI) show an impairment related to phonological abilities (they cannot repeat complex words and nonwords and have difficulties judging phonological aspects of words and segmenting words) but they performed well in the syntactic tests;

- PraSLI (Pragmatic SLI) show an impairment in discourse ability and theory of mind but their performance in purely syntactic tasks was normal.

These findings support the idea of subtypes of SLI. The dissociation found between lexical and syntactic abilities are in line with studies by Van der Lely (2005). It is important to underline that selective impairments in one module of language and not in others, do exist and it is possible to identify subgroups within SLI and this helps to identify the exact locus of deficit each child with SLI has.

3.2 A possible relation between dyslexia and SLI

As many studies confirm, there should be a relation between dyslexia and SLI because there have been abundantly reported the language impairment observed in dyslexic children and in children at risk of developing dyslexia, as the reading impairment in children with SLI. The incidence of reading difficulties in children with an history of SLI is high, between 40 and 60% (Catts, Hu, Larrivee & Swank 1994) and there is a general consensus on the fact that children with persistent and severe language difficulties may be at higher risk of developing difficulties linked to reading. These data suggest that dyslexia and SLI should be related impairments, even because a diagnosis of dyslexia and SLI can coexist in the same children as confirmed by language tests which revealed that about the 50% of both groups of dyslexics and SLI children satisfied the criteria of alternative diagnostics (Vender 2011). These results have highlighted the question if this reading impairment may be carachterised by a phonological deficit similar to that retraceable in dyslexia and a possible answer arised from direct comparison of reading and language profiles of dyslexics and SLI children, suggesting that there may be at least a partial superimposition between the two groups for what concerns language abilities and, in particular, on phonological processing. For example Carrol and Snowling (2004) confronted the phonological processing, the phonological acquisition, the phonological awareness and the emergence of the reading abilities in children between 4 and 6 years old at risk of dyslexia and children with language difficulties. the results showed similar performances for both groups, but the performance of the group at risk of dyslexia stopped at an intermediate level between the control group and the SLI group.
This superimposition of symptoms and results suggested that there may be a strict connection between dyslexia and SLI and this has generated a great interest in researchers whose researches stemmed from two possible interpretations: dyslexia and

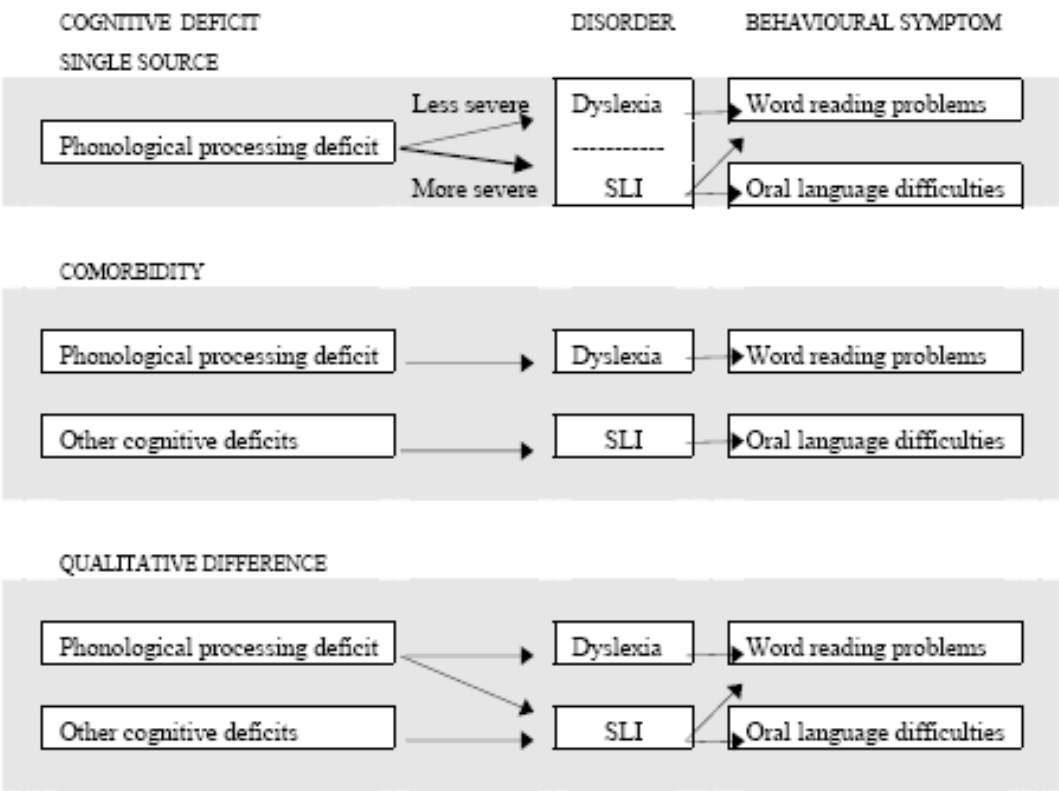
SLI are impairments qualitatively similar with language difficulties which manifest themselves in early age and with reading difficulties attested in school age, whereas the second point of view is that there may be similarities between dyslexia and SLI, but these impairments remain different (Bishop & Snowling 2004).

Two theories elaborated about a possible relation between dyslexia and SLI sparked a debate between researchers and scholars. Tallal et al. (1997) proposed the single source hypothesis, unifiying dyslexia and SLI in a broader category named language acquisition impairment with reference to the children affected by reading and/or language difficulties. According to their theory, reading and language difficulties may be originated by a basic deficit of temporal processing which would interfere with the auditory processing of very fast acoustic transitions of spoken language and this would have an impact on speech acquisition and, in its turn, to the acquisition of language including linguistic representations. Tallal et al. postulate the existence of a developmental continuum between language deficits and reading reding difficulties based on phonology and stated the age as a primary factor that distinguishes the developmental language impairment from the reading difficulty. The difficulties with rapid auditory processing would be the basis of poor phonological elaboaration, of language difficulties and of dyslexia. According to this vision, there are no differences between the two impairments and they would be manifestations of the same difficulty and the only difference would consist only in the severity of the manifestations: SLI can be considered the most severe manifestation of the impairment and appears in the early age while dyslexia can be considered a less severe manifestation of the impairment and appears later.

Other researchers, as Catts et al. (2005) diverged from unifying diagnostic cathegories, or treating them as points on a severity continuum rather than as distinct impairments. The model proposed by Catts et al. (2005) with the comorbidity hypothesis they

proposed that dyslexia and SLI should be distinct impairments but coexistent, stating that they would be distinct developmental disorders with different cognitive deficits and different behavioural expressions. As we have already seen, both children with SLI and children with dyslexia show difficulties in oral language.

Image 1 Models of relation between dyslexia and SLI based on Catts et al. (2005)

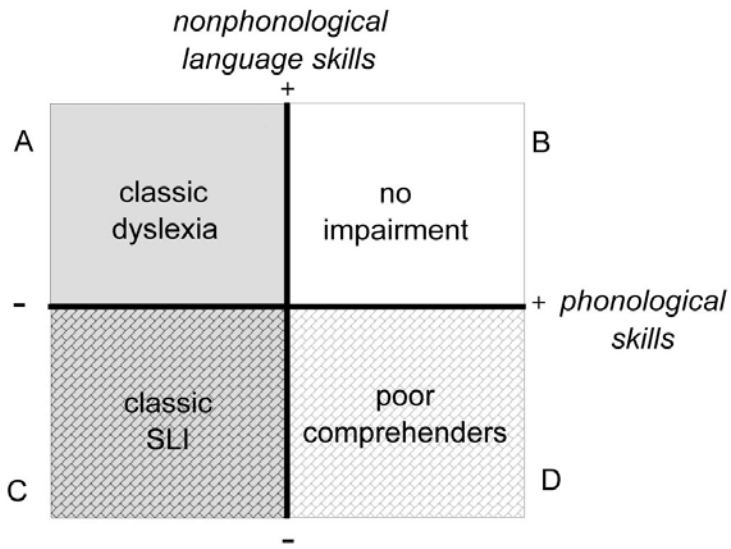


On the same line we can take into account the model proposed by Bishop and Snowling (2004) who proposed the qualitative difference hypothesis, highliting the fact that a single dimension of severity is not sufficient to capture the wide clinical variation that exists in these disorders. They admit that there are some similarities between dyslexia and SLI in the phonological defict observed, but they generally believe that children with SLI have further syntactic and semantic difficulties that also affect their oral language. The two reasearchers are convinced that the current perception of dyslexia

and SLI underestimates the role played by the syntactic and semantic difficulties in obtaining a fluent reading. They also propose some reason that should validate the idea that dyslexia and SLI are two different disorders:

- Disorders that appear similar at behavioural level, may have different causes: if children affected by SLI and affected by dyslexia show similar behaviours, this does not necessarily mean that the disorders are qualitatively the same;
- Non-phonological aspects play a key role in the acquisition of reading abilities: a detailed analysis of reading development in children with SLI showed that their reading difficulties are slightly different from the difficulties observed in dyslexics. In particular, a poor comprehension of written material is a prominent carachteristic of SLI rather than of dyslexia;
- The results of neurobiological and etiological studies on dyslexia and SLI cannot support the unification of the two theories: from the neurobiological perspective every attempt to merge the results of the structural studies on the brain with the functional imaging techniques of dyslexia and SLI is obstacle by the incoherence af the results from a study to the other. For what concerns genetics, many studies show how the phonological processing deficit may be inheritable and confirm that the phonological dyslexia is inheritable whereas it is much less clear if reading disabilities associated to semantic and syntactic difficulties (that is the predominant disorders in SLI) may be inheritable.

Image 2 The two-dimensional model of the relationship between Dyslexia and SLI proposed by Bishop and Snowling (2004)



This two-dimesional model shows how phonological and non-phonological abilities contribute or not to the dyslexia profile (A) or SLI (C), poor comprehenders[6] (D) or with no impairment. For what concerns SLI both the phonological and non phonological abilities contribute independently to the disfunction, whereas classic dyslexia is characterised by a phonological damage but shows relatively intact non-phonological language abilities. Poor comprehenders share with SLI children non-phonological difficulties but they do not show any phonological difficulty.

This model accounts for the phonological difficulties in dyslexia and with SLI. The two researchers recognise the existence of children with profiles halfway to the categories presented and that there are additional variables to take into account like visual perception, speed of elaboration and attention.

Comparisons between recent studies on phonological and grammatical abilities reported not only similar phonological difficulties for dyslexics and SLI, but also

[6] With the term poor comprehenders we refer to children who can normally and accurately read, their IQ is within normal limits,with spared phonological abilities but they cannot understand what they read and their deficit seems to be retraceable in a weak vocabulary and in a limited semantical knowledge.

differences between groups for what concerns grammatical abilities. These results that seem in line with the qualitative difference hypothesis (Fraser & Conti-Ramsden 2005 on British English; Puranik, Lombardino & Altmann 2007 on American English). Both studies reported phonological difficulties as low spelling accuracy in both groups and differences in grammatical abilities as in speech production, partially damaged in dyslexics. These studies highlight that the profiles of children at risk or dyslexics differ from the profiles of children with SLI with an overlapping for what concerns the impoverished phonology but not necessarily for reduced grammatical abilities. These results are very cogent because they establish the existence of difficulties in the phonological domain. More specifically, failures were observed in the deletion of phonemes, where not only the group at risk but also the SLI group had a worse performance than the control group.

The fact that a substantial number of children affected by SLI showed phonological difficulties seems not to corroborate the comorbidity hypothesis according to which only SLI children with a comorbidity of dyslexia show phonological difficulties. These results seem to corroborate the qualitative difference hypothesis, stating that SLI and dyslexia wuould be distinct impairments, both of them showing difficulties in the phonological domain. Another advantage represented by this theory is the classification of dyslexia as a multirisk disorder that allows to read it as a disorder with multiple risk factors interacting at genetic, environmental, neurobiological and cognitive level. A similar model has been proposed for SLI. Both disorders can be qualified by insufficient phonological abilities, but both also depend on other risk factors.

Other etiological factors can hint a possible relation between SLI and dyslexia. Both tend to occur at family level and the same impairment can be observed in members of the same family; moreover, studies (Flax et al. 2003) suggest that it is easier to find individuals affected by a speech disorder in the family of a child with this kind of

disorder rather than in the family of a child without that kind of disorder. Many studies (Hallgren 1950, Lubs et al. 1993) proved that relatives of dyslexics have a higher risk of developing reading disorders. Hallgreen studied clinical histories of the relatives of 300 children with reading deficts and observed that the 88% of the children had a relative with a reding disorder and proposed that dyslexia may have a genetic trait. Although studies and well documented histories of families with reading disabilities suggest a genetic component in dyslexia this is not enough to explain the involvement of genes. Gopnik & Crago (1991) studied the possible genetical transmission of SLI. They studied three generations of an English family (the KE family) and concluded that about the half of the members of children with SLI showed language disorders. All of them had a gene mutation while this was completely absent in non-impaired subjects. These results are controversial and many studies believe that the problems observed in this family may not be SLI. For example Vargha-Khadem (1998) studied more specifically the case and argued that there was any specific grammatical or speech disorders. Studies conducted on SLI twins provide evidence for the genetic contribution. Bishop (1992) found an effect of 67% for identical twins and for the 32% for etherozygotics. Although environmental factors do not cause dyslexia or SLI, it is largerly believed that this may influence reading abilities or speech production. The main environmental factors strictly linked with dyslexia are educational experiences and the family environment. Conventional definitions of dyslexia tend to exclude all the reading problems caused by an inadequate exposition to education, but studies on reading abilities conducted on children attending different schools of the same geographical area highlighted that the education may have a significant effect on reading abilities (Rutter & Maugham 2002). Whereas, for what concerns the family environment, this may influence children's reading success (Whitehurst & Lonigan 1998), but the comprehension abilities more than reading seems to be influenced.

For what concerns SLI, several environmental factors are indicated as possible causes of the disorders but any of these seemed necessary of sufficient to cause the impairment.

4. A brief history of the study of dyslexia

We can assume that dyslexia has always existed since the birth of humanity, even before the development of writing systems however the invention of press by Gutemberg helped towards the popoularity of reading and writing, which before was available only to an elite group. The origins of mass reading are much more recent, linked to the birth of an institutionalised public education. Only in the nineteenth century in Great Britain an act guaranteed a basic level of education to all children. This event meant that, from then on, educators could observe a large number of children at school allowing them to identify those who have reading problems, as for example developmental dyslexia. (Guardiola 2001).

In 1895, James Hinshelwood, a British ophthalmologist, published a series of articles in many medical journals, as The Lancet, describing issues of congenital *word blindness* and *visual memory*. He also hypothesized that this condition would be less rare than it seemed on the basis of the low frequency with which it was recorded. This inspired W. Pringle Morgan, a British physician, who in 1895 published an article on the British Medical Journal describing a case of a 14-year-old-boy who had not yet learned to read, but showed normal intelligence and was generally used to take part in other activities typical of children of that age. For this reason, Morgan is known as the father of Developmental Dyslexia.

Another important figure in the history of dyslexia is Samuel Orrey Orton who, between 1925 and 1948, modeled the evolution of the study of dyslexia. He analysed developmental dyslexia and coined the term *strephosymbolia*, or twisted symbols, explaining that subjects who suffer from developmental dyslexia show difficulties in connecting the visual forms of the words with their spoken form. He also argued that

the reading impairment may stem from strictly visual deficits possibly due to a brain malfunction.

Between 1890s and 1950s, developmental dyslexia had been studied mainly by physicians in particular by ophthalmologists and neurologists. Then, after Orton's research studies on developmental dyslexia became an interesting field of investigation for psychologists, sociologists and pedagogues, who began to discuss about environmental and psychological factors that could be connected with the difficulties of developmental dyslexia like the educational method and family life.

Between 1950s and 1960s, researchers started to support the hypothesis that developmental dyslexia would be a disorder of multifactorial origin, therefore they identified subgroups with different problems.

Only in the 1970s a new hypothesis emerged: developmental dyslexia could stem from a phonological system deficit. This hypothesis came from the evidence that dyslexics have difficulties in recognising that words of their spoken language are composed by phonemes and also in connecting sounds to the corresponding alphabetic letters of the written language.

After 1970s theories on developmental dyslexia based on new disciplines like cognitive psychology and neurosciences provided more compelling results.

In the field of psychology, Isabelle Y. Liebermann supported the hypothesis that dyslexics' difficulties in reading would be of linguistic origin, in particular they originated from the phonological structure and segmentation. Many researchers followed this line and observed phonological impairments in dyslexics, like for example a poor phonological awareness.

Luria (1974), suggested that the observed difficulties in naming tasks affected speech, and that reading, writing and speech are all aspects of the same activity.

Vellutino (1979) discovered a correlation between phonological deficit and short-term memory deficit in normal readers. In his opinion developmental dyslexia is not a visual disease, but a language deficit that involves the phonologic processing of words.
Tallal (1980) proposed her theory of a deficit in the processing speed of general information, since she observed the relationship between slow auditory processing of words and sounds and language deficits.
Galaburda and Kemper (1979) found symmetry in the temporal plane, where there should be asymmetry and cellular lesions in the brain of a 20-year-old dyslexic who died accidentally.
Between 1980s and 1990s Margaret Snowling, an English psychologist, found a correlation between phonological skills and short-term memory of dyslexics.

5. Dyslexia in Italy

Before the 1960s, in Italy, there were no papers about developmental dyslexia published on Italian or foreign specialised magazines and until a few years ago, pupils who do not learn to read were considered indolent, incapable of striving with the serious consequence that there won't be taken compensatory measures to contain or, at least, to ease the issue.
There are 2 main factors that delayed the recognition of dyslexia in Italy: the relative ease of the Italian orthography and the imbalance of Italian clinical psychology, above all the developmental psychology, towards psychodynamic interpretative models.

5.1 The ease of the Italian orthography

The ease of the Italian orthographic system is a protective factor with respect to the emergence of reading difficulties and for this reason, children with written language processing disorders may have less difficulties compared to their English peers that have to learn a highly irregular orthographic system. It is important to underline that this easiness is typical of written Italian and therefore, for other languages, the acquisition is not so sudden, and it is not so rare to find children with difficulties in reading and learning.

Learning to read Italian is so easy that many children learn to read on their own before starting primary school, maybe with their older siblings. At the end of the first year of primary school, 90% of pupils between 6 and 7 years can easily read a book of fiction for children. Those who do not learn to read are excluded, considered like black swans, a rarity that stands out in the mass of pupils who learn without effort the correspondence between signs and sounds.

This is, without any doubt, one of the reasons that lead to a late discovery of the existence of dyslexia in Italy.

5.2 The approach of clinical psychology

The Italian clinical psychology is still today recluctant to accept the information related by neurosciences on the origin of reading disorder and continues to consider dyslexia as an essentially emotional or relational disorder (Vender 2005). Dyslexia would rely on the anxiety that triggers the school performance in children, or in a bad relationship between pupil and teacher. This would be a manifestation of some issues that the children would live in the family and that expresses in a right way, through a modality that does not force him/her to take a position in the conflict between the parents, succeeding in having the attention of both. The difficulties in learning may originate form a conflicts of competitive nature with siblings (the envy for the older or jealousy for the younger) or, in general, for peers.

In other words, there are many explanations for reading disorders, many of these classify them as “of psychological origin” recalling an emotional distress that is always traceable in dyslexic children and often are more noticeable than reading disorders. Behavioural disorders manifested by the pupil who wants to avoid homework, are, for the teacher, much more disturbing than reading errors. However, it is proper to avoid to confuse causes with effects: behavioural or relational problems described above are often the effect of repeated frustrations, rather than the cause.

5.3 Dyslexia in Italian schools

Recent official statistics provided by the Italian Dyslexic association (AID[7]) reveal that dyslexia affects between the 4% and the 6% of the population. According to the statistics provided by the Veneto region in 2006, dyslexics were:

- The 4,5% of scholastic population;
- Almost the 10% are foreigners;
- The 2% are disabled;
- Another increasing share is at high risk for families in crisis, international adoptions and so on.

To complete the picture, it is necessary to argue that the extension of compulsory education kept in the classes many critical situations that otherwise would be expelled from the educational system.
In these last few years, much has been done for teachers and headmasters of schools at all levels with specific training courses organised by the Ministry of Education with the collaboration of the Italian dyslexic association (AID). The Ministry of Education also elaborated a note MIUR Prot. N: 4099/A October, 5th 2004, nota MIUR Prot. N.26/A January, 5th 2005 with adaptations regarding teaching strategies (with compensation measures), the compensation meausures and the evaluative process. But a real acknowledgement of dyslexia in Italy arrived only in 2010 with the promulgation of law n.170/2010 which has filled a legislative gap that lasted for years. This law acknowledges dyslexia as a specific learning disability, promoting the educational success through measures of educational support, reducing emotional and relational distress, preparing teachers and making parents aware in the challenges linked to the

[7] www.aidaitalia.org

specific learning disabilities and ensure equal opportunities of development of personal capacities in social and professional environment (Italian Dyslexia Association, AIDA Italia 2010).

6. Theoretical perspectives on developmental dyslexia

6.1 The visual deficit hypothesis

In the framework of the Visual Deficit Hypothesis (Eden et al. 1996), visuo-perceptual impairments are held responsible for the difficulties experienced by dyslexics in learning to read. Specifically, dyslexia is considered primarily as a deficit affecting visuo-spatial processing and causing a faulty visual perception, which in turn determines the difficulties in acquiring reading skills. The Visual Deficit Hypothesis basically constitutes the first approach proposed to explain developmental dyslexia, starting from scholars as Hinshelwood, who noted that dyslexic children seemed to manifest a strange "blindness" for words, and Orton, who suggested that dyslexics perceive letters and words as reversed forms.

Other researchers have argued that dyslexics suffer from visual processing deficits affecting visual sequences and visual memory, like erratic eye movement and eye convergence deficits, and that these problems cause their reading difficulties.

The visual theory of dyslexia was widely accepted until the 1960s-1970s, when it was severely criticized by Vellutino's seminal work (1979), in which he proved that visuo-perceptual disorders do not really play a significant role in dyslexia. Replicating some of the experiments conducted by the supporters of the Visual Deficit Hypothesis, in fact, he found that there were few significant differences between dyslexics and controls when the influence of verbal coding was controlled for instance, he noted that dyslexics underperformed when they were asked to orally recall a sequence of similar letters presented visually (e.g. "b" and "d"), whereas they performed as well as controls when a written response was required. This difference seems to suggest that the difficulties found in dyslexics are due to phonological more than to strictly visual reasons.

Moreover, it has been demonstrated that visual skills are poor predictors of reading abilities, indicating that reading difficulties cannot be determined by visual factors, but are more likely due to a linguistic impairment.
However, low-level visual deficits such as oculomotor deficiencies and visual-tracking problems have been recently found in dyslexic individuals.

6.2 The auditory deficit hypothesis

The father of the Auditory Deficit Hypothesis of dyslexia is Alfred Tomatis. At the end of the 1960s, he proposed that dyslexia was caused by an auditory deficit, interfering with the child's phonological competence.
Specifically, Tomatis and the other supporters of the Auditory Deficit Hypothesis proposed that auditory perception deficits were the core disorder characterizing dyslexia: an impaired perception of the distinctive speech sound could, in fact, determine phonological deficits and, as a consequence, reading and spelling problems. Supporters of the Auditory Deficit Hypothesis, therefore, do not deny the existence of phonological deficits in dyslexics, but rather claim that these deficits are secondary to a more general auditory impairment in sound perception.
A number of studies have examined auditory perception in dyslexics, even if only a fraction of them showed poor performance in auditory tasks. Initially, Tallal (1980, 1984), introduced this theory as an explanation of the Specific Language Impairment (SLI)[8] but, at a later stage, suggested that this theory could have explained also dyslexic problems because she found that dyslexic children display deficits affecting the rate at

[8] Specific Language Impairment (SLI) is diagnosed when a child's language does not develop normally and the difficulties cannot be accounted for generally slow development, physical abnormality of the speech apparatus, autistic disorder, acquired brain damage or hearing loss. I am going to deal with this topic in the following chapter.

which they can process incoming auditory information, since dyslexics' auditory processing was mainly impaired on short sounds and fast transitions. For this reason, the disorder exhibited by dyslexics was dubbed as "rapid" or "temporal" auditory processing deficit, giving rise to the Auditory Temporal Processing Deficit Hypothesis or Rapid Auditory Processing Hypothesis of dyslexia (Tallal 1980).

Nevertheless, this theory presents problems as well: only a part of dyslexic children, in fact, have been found impaired in auditory tests in further studies.
Moreover, Snowling (2001) and Ramus and colleagues (2003) have recently shown that there is no reliable relationship between dyslexics' performance on rapid auditory processing tasks and speech categorization and discrimination, indicating that there cannot be a causal connection between the auditory deficit and the phonological impairment. On the contrary, they observed that some dyslexics do preserve auditory abilities despite phonological difficulties. This fact demonstrates unequivocally that phonological deficits can arise in absence of auditory impairments and that therefore the poor phonological competence cannot be secondary to auditory deficits, as the Auditory Deficit Hypothesis claims.

6.3 The magnocellular theory

The magnocellular theory has been proposed by Stein (2001) as a unifying theory with the aim of assimilating all the results of the above-mentioned theories. Another significant contribution of this theory is the explanation of the visual impairment related to dyslexia.
This theory suggests that a damaged development of a neuronal system in the brain (that is the magnocells) that could be responsible both for the visual and hearing re-elaboration and for the tactile problems found in dyslexic children.

The magnocellular theory also explains the visual impairment of dyslexic subjects suggesting that they could have little control over eye movement. Stein and his colleagues believe that this little control over eye movement may be caused by a incorrect development of the magnocellular system which connects the retina to the frontal and occipital lobes, allowing the information transmitted from the eye to be drawn from the areas of the brain. The magnocells play a crucial role in many visual processes, such as glimpse the movement, its direction and control eye movement that is crucial for reading. According to the authors, a damaged development of the magnocellular system may cause a changeable eye control while reading and this could explain the agitated and blurry images reported by many dyslexic subjects.

This theory explains the auditory phonological impairments in dyslexic subjects suggesting a damage in the auditory system equivalent to that of the magnocellular visual system. In the auditory system, there is not a set of anatomically distinct magnocells, some neurons that are specialised in processing hearing transactions, changes in the frequency, amplitude and phase of sounds. An optimal elaboration of frequency and of the amplitude of transactions is essential to succeed in distinguishing between the sound of different letters. According to Stein and his colleagues, the identification of frequency and amplitude of these transactions is essential to satisfy the phonological requests of reading. A damaged development of the elaboration of auditory transactions may lead to an auditory confusion of the sounds of the letters and therefore to an hindrance in the acquisition of phonological skills.

This theory explains the cerebellar deficit in dyslexic subjects suggesting the fact that cerebellum receives an extended input from the various magnocellular systems in the brain. For this reason, the cerebellum would be affected by a general magnocellular impairment.

6.4 The phonological deficit hypothesis

The phonological deficit theory is the most known theory about developmental dyslexia. This theory assumes a damage in the representation, in the storage and also in the retrieval of the speech sounds (Ramus 2003). A necessary prerequisite for learning to read and to write is the acquisition of the grapheme-phoneme correspondence of the alphabetic system. Children must discover the connection between letters and sounds that constitute the language. Some theories explain developmental dyslexia arguing that if the speech sounds have a light representation, a light storage and a light retrieval, this as a consequence, may lead to an insufficient comprehension of the correspondences grapheme-phoneme of the language. Researchers who support the phonological deficit theory, believe that phonology may have a central and causal role in developmental dyslexia, suggesting a direct connection between a cognitive deficit and a behavioural problem.

Many studies support this hypothesis and verified in dyslexic children the presence of low-level performance in phonological awareness, that is the capability of segmenting and manipulating the speech sounds. According to Snowling (2001) also a short verbal memory and a slow automatic naming are symptoms of a phonological impairment.

In its strongest version this theory argues that the cognitive impairment in developmental dyslexia may be specific to phonology. However, this theory caused a debate still in progress. Researchers who question this theory suggest that dyslexia is a wider disorder than what the theory suggests, with an origin in general sensorimotor and learning processes. They did not call the existence of phonological problems in developmental dyslexia, but they argue that these problems may represent only one aspect of a wider disorder.

Although this represents the most influential and investigated theory about dyslexia, the phonological deficit hypothesis cannot provide a complete account for all the problems that dyslexics must face.

In this regard Scarborough (1990) commented that "plausible though this hypothesis can be, it may not provide a complete explanation of reading failure". The two most relevant limits of this theory, in fact, are that phonological deficits cannot explain all the symptoms manifested by dyslexics and, moreover, that they are not specific to dyslexia; conversely, they are also shared by those non-dyslexic individuals whose phonological competence is impaired.

Particularly significant in this respect is the experiment conducted by Byrne (1981) to assess the comprehension of the so called "tough sentences", which are characterized by very similar phonological structure but a completely different underlying syntactic structure[9]. As shown by Byrne, those sentences which were more complex from a syntactic point of view are much more difficult to understand for dyslexics in comparison to less complex, but phonologically similar, sentences. If phonological limitations were the only deficit characterizing dyslexia, one should not expect this difference. Dyslexics, in fact, should rather show the same performance with syntactically more complex and simpler sentences, given that their phonological structures are very similar.

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[9] The sentences proposed in the study were for example:

1) The snake is glad to bite;
2) The snake is hard to bite;
3) The snake is horrible to bite.

The three sentences seems ideantical but the underlying grammatical relations differ (Vender 2011).

6.5 The cerebellar theory

The problems observed on dyslexic children do not only concern reading, but seems that their ability of accomplish some skills in an automatic way is generally damaged. It is believed that this skill depends on the cerebellum.

The cerebellar theory, proposed by Fawcett and Nicholson (2004) has a biological basis and argues that dyslexic children's cerebellum may be slightly dysfunctional causing cognitive difficulties even because the cerebellum plays a crucial role in motor control and, as a consequence, in the articulation of speech. The authors explain the phonological problems in dyslexic children arguing that a dysfunctional articulation may lead to impoverished phonological representations. What is more, the cerebellum is instrumental in the automation of skills such as typing, driving and reading. It is reported that in many dyslexic children these abilities are impaired.

This theory is confirmed by the difficulty of many dyslexic subjects with motor tasks, with the execution of two simultaneous tasks and with the perception of time.

To sum up the causes of the difficulties of dyslexic subjects may be divided in two main groups: on the one hand, the phonological theory that ascribes dyslexia to a phonological deficit and on the other hand, the magnocellular deficit that ascribes the inability of reading to a general sensorial deficit, like for example a visual, hearing or motor deficit.

The main weakness of the phonological theory lies in the fact that it doesn't explain the presence of sensomotorial deficits in dyslexic subjects. Even the cerebellar theory cannot explain the presence of these deficits.

In 2001 Fawcett & Nicholson proposed the existence of two subtypes of dyslexia to explain the presence of different types of symptoms: it is possible that some dyslexic subjects have a damage in their cerebellum and others may show a damaged

magnocellular way. Of course, this is plausible but the cerebellar theory raises another problem: the causal relation postulated between articulation and phonology is based on a outdone version of speech perception according to which the development of phonological representations could be based on speech articulation. This vision has been abandoned long time ago in the light of the existence of a normal phonological development despite the presence of a severe dysarthria[10] or apraxia[11].

At first sight the magnocellular theory seems to be the most engaging but the predictions of this theory regarding the visual auditory elaboration have been widely criticised. For what concerns the auditory deficit the major problem is that different researchers did not succeed in repeating the results of the auditory deficit in developmental dyslexia, and when they found some results, these were isolated to a small group of subjects.

Another criticism is connected with the results of many studies that are incompatible with the idea that the auditory deficit (when it is present) can be found in the rapid auditory elaboration.

For what concerns the auditory and visual deficit subsumed by the magnocellular theory the defict may be concentrated in the magnocellular system and the criticisms are concentrated on the unsuccessful repetition of the controversial and inconclusive results of the visual deficits. Dyslexics have an impairment causing reduced sensitivity to rapidly changing stimuli, arising reading and spelling deficits as well as phonological weaknesses. If we accept the existence os sensory defects as one of the possible explanation of dyslexia, grammatical, vocabulary and attentional deficits cannot be explained.

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[10] Dysarthria is a motor speech disorder resulting from a neurological injury of the motor component of the motor-speech system and it is characterised by poor articulation of phonemes.

[11] Apraxia of speech is an oral motor speech disorder affecting an individual's ability to translate conscious speech plans into motor plans, which results in limited and difficult speech ability.

However, it is not clear this what proportion of dyslexic subjects that have a given deficit is and whether dissociations or systematic associations between different types of deficits may exist.

In this sense, Ramus (2003) tried to answer these questions. She studied 16 dyslexic adults and 16 control subjects, all university students, in a complete battery of psychometric, phonologic, auditory, visual and cerebellar tests. The data reveal that all the 16 dyslexic subjects have a phonological deficit, 10 of them have an auditory deficit, 4 a motor deficit and 2 a magnocellular visual deficit. As a conclusion we can assume that the phonological deficit can occur without any other senso-motor deficit and the phonological deficit alone is sufficient for causing reading problems. The auditory deficit, when present, to a certain extent worsens the phonological deficit. Of great importance is the fact that the auditory deficits cannot be classified as rapid auditory deficits or *speech perception deficits*.

Ramus (2003) did not find an influence of the moto-cerebellar performance on phonology or on reading questioning the accidental role of the cerebellum in dyslexia. Auditory deficits with magnocellular origin have a low bearing. This low incidence and the fact that visual deficits were present with phonological and auditory deficits does not clarify the evaluation of the contribution of visual defictis in particular if they can be considered completely independent of dyslexia.

In a more recent study, White et al. (2006) investigate the sensomotorial dysfunctions (visual, auditory, motor) that may be connected with reading impairment. White et al. administered to a group of dyslexic children and to a group of autistic children a series of reading, auditory, phonological and motor tests.

As previous studies confirmed, only a part of the dyslexic children showed a sensomotor deficit and this suggested that a double dissociation between the sensomotor and reading impairment may exist. Therefore, dysfunctions on the visual, auditory or motor

system cannot be responsible for the phonological impairment of dyslexic. The sensomotor impairments found in dyslexic subjects are extended also to autistic children, who do not necessarily show difficulties in reading and in learning writing skills.

6.6 The working memory deficit

Before starting talking about the close relationship between working memory and developmental dyslexia, it is proper to briefly outline the structure of the memory and of the working memory as it has been hypothesised by many studies and to highlight its connection with language.

6.6.1 Memory systems

A large number of memory traces is formed through language and, in its turn, it is used to express many memory forms. Only recently the relationships between memory and language have been studied and this is because patients affected by memory deficits did not necessarily show also language disorders.

Different cerebral structures specifically intervene on determined memory aspects and this is also revealed by fMRI studies which reveal if a cerebral area is involved in specific functions. Data provided by patients that show localised cerebral injuries are of fundamental importance because they tell if a certain cerebral structure is essentially necessary or not for a determined function as, for example, valuable information on the specific function of various parts of the cerebral cortex has been obtained from patients with brain injuries caused by cerebral illnesses or by brain operations (Swaab 2010).

In 1890 the American psychologist William James hypotheiszed the existence of a primary memory (nowadays called short-term memory) with a limited span, and a

secondary memory (nowadays called long-term memory) which is linked to longer lasting knowledge of a person.

6.6.2 Long-term memory (LTM)

The long term memory is defined as the continuing storage of information that can last there for a matter of days as long as many decades. The information stored are largerly outside awareness but can be recalled into working memeory when needed.
The long-term memory is divided into:

- Declarative memory: refers to the kind of knowledge to which you can access consciously (explicit knowledge). The declarative memory can be divided into the semantic memory (refers to words, concepts, their properties and mutual relationships, and also to the set of encyclopaedic knowledge about the world) and the episodic memory (refers to experiences of the past that we are able to voluntarily recall and tell) (Tulving 1987);
- Procedural memory: is an implicit memory which involves memories of body movement and how to use objects in the environment. This type of memory is used automatically and without conscious access, and the information stored cannot be described verbally.

6.6.3 Short-term and working memory

The short-term memory maintains available a limited quantity of informational units (as words, numbers, positions in the space) for periods of time that may vary from some seconds to some minutes.
A subcomponent of the short-term memory is the working memory.

Working memory

The pre-frontal cortex is the cerebral structure delegated to a number of functions and also coordinates different cerebral areas that constitute the working memory or the sort-term memory. For what concerns the working memory exerts its function collaborating with the hippocampus supporting concentration and attention and selecting the stimuli. The words that are easier to remember in a test are those that increase the activity both of the prefrontal cortex and of the hippocampus area. For example when we want to digit a telephone number and we succeed in forgetting it immediately after thanks to the working memory whereas if repeating it a number of times we can register it as long-term memory. The working memory, for a short-term registration is fundamental to carry out complex tasks and to act in a targeted way.
The analysis of the sub-components of the working memory brought Baddeley (2003) to develop not only this concept but also its main components: the phonological loop, the visuospatial sketchpad and the central executive.

The phonological loop

The system that has been widely implied in the studies on language development is the phonological loop or verbal operative memory. It concerns the speech and maintains the order in which words are presented. A sub-division into 2 components of this system has been proposed: a temporary storage system that maintains the information in the memory for some seconds during which they decay if they are not reinforced by a second component. This second component involves a low-voice repetition system that not only maintains the information but also records the visual information in the memory provided that the elements can be named. Thus, if a sequence of letters for a repetition task, is presented to a subject despite its visual presentation, the subjects repeat in a low voice and its retention in a crucial way will depend upon the acoustical

or phonological characteristics of the letters presented in the sequency. For this reason, the phonological loop is characterised by some phenomena such as the *effect of phonological similarity*, in which the words that are similar on the phonological level are remembered worse; and the *effect of word length* in which a sequence of short words is easier to be produced than a sequence of longer words.

Many studies confirm the importance of the phonological loop in language acquisition. For example, Blake et al. (1994) found a relationship between verbal memory and the specific evolutionary characteristics of spontaneous speech in three-year-old children. Adams & Gathercole (1996) observe that differences in the phonological memory skills in preschoolers were associated with differences in narrative oral abilities. Adams and Gathercole (2000) showed that the phonological working memory in 3 or 4 years-old children is related with the extent of their productive vocabulary, to the length of the sentences they produce and to the different syntactical constructions they use in their spontaneous speech.

The visuospatial sketchpad

This subsystem of the working memory integrates the spatial, visual and perhaps also the kinesthetic information in a unified representation that can be temporarily stored and manipulated. Clearly the visuospatial sketchpad is less important than the phonological loop in language disorders. However, it seems that this system is involved in reading skills, especially in the maintenance in the representation of the page and in its graphic representation that remain stable and will simplify some tasks as carefully moving the eyes from the end of a line to the beginning of the following.

The central executive

This system is responsible for monitoring attention in the working memory and can be fractioned in different executive process. These process probably are one of the main factors that determine individual differences in working memory tests. In the studies that examined working memory, subjects are required to simultaneously combine processing and storage, for example reading some sentences and at the same time remember the last word of each sentence and then repeat it. It has been proved that differences in the working memory may influence a wide range of complex cognitive abilities, from reading comprehension to learning electronics.

6.6.5 Working memory and language

Many studies suggest that working memory could be involved in language processing and that working memory deficits may have an impact on language processing even because the awareness of what is learnt is typically expressed through the language and should be linked to non-declarative memory whereas according to other experimental evidences the necessary knowledge to comprehension and expression in a language can be in large part linked to the procedural memory. Some data support the idea that we are not aware of acquisition and use of syntax, in particular of the first language syntax, nor of the sensomotoric activities necessary to the production of phonemes (Pinker 1994). Studies on developmental psychology show that in the early stages in which children have limited lexical capacities, they seem to expertise grammatical tasks (Parkin 1993). This dissociation seems to be connected to the earlier maturation of of implicit memory in contrast with explicit.

As some studies confirmed, patients who suffered from anterograde amnesia can learn new grammatical elements of a foreign language like pronouns or adverbs in spite of the severe difficulty of learning new words of the mothertongue. It seems that in spite

of the deficit some aspects of the language can be learnt and used in an implicit form. In general, the frontal lobe structures organise the syntactical components of a language only if this is acquired within a certain critical age, after which other brain structures taken in charge to organise the grammatical aspects of a second language and it is likely that these substitutional structures admit the learning on explicit basis.

To sum up, the acquisition of a mother language seems much more linked to implicit memorisation however, even in the first language are constantly involved of both components of implicit memory and of explicit memory for example during comprehension there is a simultaneously activation of components of semantic memory (explicit) for the recognition of lexic and components of implicit memory for syntactical comprehension.

During the 90s many models about the working memory have been suggested but the most influential one has been proposed and developed by Baddeley (1986). According to this model, the working memory is a system whose function is the temporary maintenance and the manipulation of information presumably necessary in a wide range of complex cognitive activities. In 1974, Baddeley & Hitch argued that working memory could be divided into 3 different constituents which presumably work together with the function of facilitating the performance in different cognitive tasks. The three components, as represented in Image 3, consist of a storage unit for the temporary maintenance of verbal and auditory elements named *phonological loop*, and an attentional system with a limited capacity named *central executive* that copes with cognitive tasks, organising the codification of information and temporarily activating the long-term memory.

Neurological correlates of the distinct working memory components have been found: the central executive is situated in the frontal lobes, the phonological loop is in the left hemisphere and the visuospatial sketchpad is in the right hemisphere.

Image 3 The components of working memory (Baddeley & Hitch 1974)

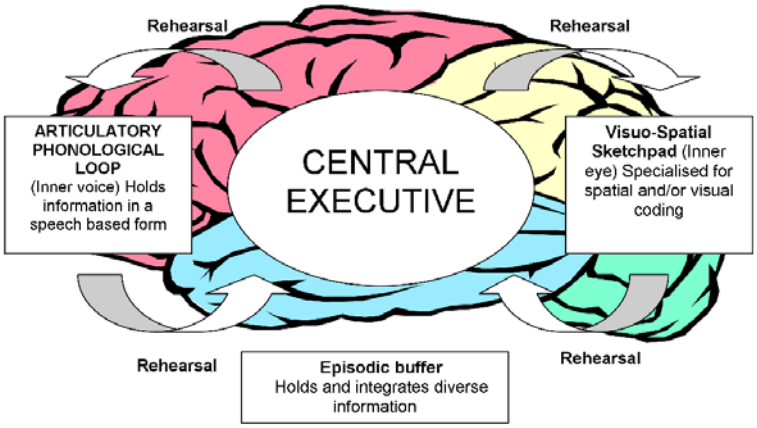
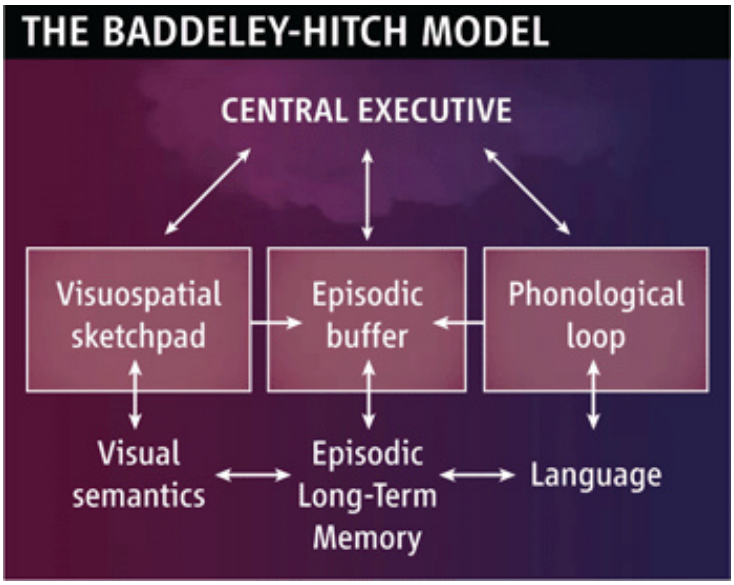


Image 4 The Baddeley & Hitch model of Working Memory



6.6.2 Working memory and dyslexia

"Developmental dyslexia is a genetically inherited and neurologically determined inefficiency in working memory, the information-processing system fundamental to learning and performance in conventional educational and work settings. It has a particular impact on verbal and written communication as well as on organisation, planning and adaptation to change" (McLoughlin et al. 2002 p.19)

Given the crucial importance played by WM in cognitive skills, it has been hypothesized that dyslexia is due precisely to a working memory deficiency. Specifically, this proposal has been introduced by McLoughlin et al. (1994) who argued that working memory impairments are responsible for all the primary difficulties experienced by dyslexic children.

Alloway et al. (2004) trough the use of a battery of tests, provided the demonstration of a significant connection between the working memory skills and the success in reading and in comprehension. In particular, they concluded that the dimension of the working memory span (calculated through tests that evaluate working memory skills) may predict the reading and comprehension. Gatercole et al. (2006) obtained similar results and demonstrated that the score achieved in the verbal working memory measurement significantly predicts the success in reading. Moreover, Gathercole et al. (2006) tested a group of children with reading disabilities and observed that the difficulties in learning to read are associated to the abilities of the verbal working memory.

A more precise and recent hypothesis claiming that dyslexia is related to a working memory impairment has been proposed by Fiorin (2010) whose proposal is formalised in the Verbal Working Memory Deficit Hypothesis, according to which dyslexic subjects

suffer from a deficit affecting the dynamic dimension of the phonological loop. This deficit is also likely to affect the grammatical loop and additional component added by Fiorin to Baddeley's model and supposed to be concerned with storage and manipulation of grammatical representation.

Proceeding step by step, Fiorin started his analysis observing that difficulties shown by dyslexics in tasks involving the phonological memory, such as the digit span task, point to a first and fundamental impairment affecting the phonological loop. In particular, he proposed that this deficit does not involve the whole loop, but only its dynamic component, that is the articulatory rehearsal process. In an implementation of Baddeley's original model, Fiorin suggested that the phonological store can be seen as a 'static' dimension concerned with the temporary storage of phonological material, whereas the articulatory rehearsal process has a dynamic dimension "responsible for accessing the information in order to store it, refresh it and make it available to other system" (Fiorin 2010, p. 91).

Referring to Ramus and Szenkovits (2008), who proposed that dyslexics have a specific deficit affecting the access to phonological representation, Fiorin argued that it is precisely this dynamic dimension that is affected in dyslexic subjects. This impairment is held responsible for the phonological deficits shown by dyslexics and for their difficulties in tasks requiring that phonological representations are accessed for external computations

In other words, the author proposed that dyslexics suffer from an impairment impending them to access the phonological representations necessary for external computations. Fiorin recognised that dyslexics' difficulties are not limited to phonology but are extended also to grammar.

The verbal working memory deficit hypothesis is able to explain phonological, reading and spelling deficits arguing that the component deputed to access phonological

representation in working memory is disrupted in dyslexics. Moreover, although the author did not explicitly mention naming deficits, the hypothesis can also explain the difficulties exhibited by dyslexics in rapid naming tasks. It can also account for grammatical deficits, postulating the existence of a further component, the grammatical loop which can be disrupted by the impairment affecting the phonological loop given the neurological proximity of the two components.

Despite the formal elegance of this theory, this hypothesis faces a potential problem given that it is not able to explain the attention deficits that have been reported in dyslexic children. It seems, therefore, that Fiorin's hypothesis needs to be further implemented in order to account also for these deficits.

McLoughlin et al. (2002) suggested that dyslexic people have a weakness with low order processing in the phonological loop, as demonstrated by their poor performance in tasks affecting verbal working memory and with very demanding language tasks their central executive gets disrupted.

More specifically, the phonological loop of the working memory are believed to be impaired. Pickering (2000) observes that dyslexic subjects seem to use the phonological loop less efficiently and seem to have problems in translating the visual information into a phonological form. According to Pickering, this may involve their abilities in learning new words during reading. Moreover, dyslexic subjects show difficulties with the phonological repetition and don't seem to use phonological memory strategies as, instead, non-dyslexic people do.

Similar results were obtained by Jeffries & Everatt (2003). They compared adults performance with that of dyslexic children with the aim of evaluating the operation of the phonological loop and of the visuospatial sketchpad. They found that dyslexic subjects, differently from the control group, have many problems in the tasks that require the involvement of the phonological loop but showed the same abilites of the

control group for what concerns the visuospatial sketchpad. Dyslexic subjects also showed an impairment also in the central executive component. They also tested a group of dyspraxic subjects[12]. What is significant is that they found opposite results: these subjects showed an impairment in the visuospatial sketchpad while the phonological loop seemed to be spared.

[12] Dyspraxia is a chronic neurological disorder beginning in childhood that can affect planning of movements and co-ordination as a result of brain messages not being accurately transmitted to the body.

7. Dyslexia and adulthood

According to Satz and Van Nostrand (1973) the pattern of reading acquisition of diyslexic children resembles that of normal young readers, their skills would develop continuously throughout childhood, and that their ultimate reading achievement would eventually equal the mature levels reached by normal individuals. Whereas, according to the theories which focus their attention on qualitative differences or on processing deficits as the source of reading problems, this "catch-up" in reading achievement by dyslexics would not necessarily occur. Little evidence of this situation has been observed in studies reporting the developmental progress of dyslexic children across relatively short intervals during the school years and only in a few cases a substantial acceleration of achievement has been observed (Muehl & Forell 1973, Rutter & Yule 1975, Rourke 1976). The predicted "catch-up" should only occur after a deceleration and it is noted only in the course of the normal process of reading acquisition. Scarborough (1984) examined the literacy skills of a large group of adult readers analising the results in terms of subjects' educational histories and current intellectual abilities. She found that adults who had experienced reading problems in childhood continued to exhibit poorer reading than their peers involving other disabilities as, for example, in phonology, orthography or prose comprehension. Scarborough's results validate Miles (1993), who suggests that spelling performances is one of the indicators of dyslexia in adults. His study compared the spelling performances of dyslexics and non-dyslexics students in higher education, to determine whether spelling ability would differentiate between the two. Although Miles argues that adults with dyslexia may not show evidence of poor performance in untimed single-word reading tests, there is substantial corroboration of the hypothesis that children with good single-word reading skills may still be poor comprehenders. The results of the study conducted by Everatt

(1997) appear consistent with the findings of Miles (1993) that poor spelling ability continues in adulthood. At the same time, comprehension results show that individuals with dyslexia show evidence of continued reading problems. The study conducted by Everatt focuses on rapid naming of familiar items; the results show that dyslexics' performances did not differ from the non-dyslexic counterpart. These findings suggest that mature dyslexics are able to use some form of compensatory strategy which gives the appearance of normal functioning. As predictable, when presented with unfamiliar information, individuals with dyslexia are slower than controls.

According to Ehri (1992) and Rack, Hulme, Snowling and Wightman (1994) learning to read from the outset requires the child to set up direct mappings between orthography and phonology. Children who have well-specifed phonological representations are in advantage in this process eventhough they may not be consciously aware of the letter-sound relationship they are exploiting. According to this view, dyslexic children have poorly specified phonological representations at the time when they come to the task of learning to read. In this sense, a few studies have investigated adults with childhood diagnoses of dyslexia and found found evidence of persistent phonological deficits. For example, Felton, Naylor and Wood (1990) studied 115 adults who had experienced literacy difficulties as children. The results show that they were impaired compared to the age-matched controls on tests of rapid naming, phonological awareness and non-word reading. Using a more stringent design dyslexic adults were compared not only to normal readers of the same age, but also to younger reading age-matched controls. In this sense, the study conducted by Pennington, Van Orden, Smith, Green and Haith (1990) reported weaknesses in non-word reading and also in phoneme awareness. Bruck (1990) confirms that adults with a history of dyslexia attain lower levels of reading and spelling than their peers of equivalent IQ and continue to experience phonological processing difficulties, including problems with non-word reading and phonological

awareness in relation to reading age controls. These studies reveal that dyslexic children can make progress in learning to read but they experience persisting difficulties with non-word reading and phonological awareness, even into adulthood. As for the phonological deficit theory, Snowling et al. (1997) suggest that its success lies primarily on the ability to account for the behavioural signs and symptoms associated with dyslexia in childhood. In addition to the impairments of spoken language processing, the theory can be extended to produce a credible account of why dyslexic children have difficulties in learning to read. In particular, children need to become aware of the phonological segments of spoken words in order to appreciate the alphabetic principle which underlines the English orthography in this case (Byrne, Fielding Barnsley 1989). Children who acquire such awareness early can abstract the relationship between letters and sounds and use these productively as a self-teaching device. As a result, in the tests administred by Snowling and Nation, the dyslexic student performed worse than age- and educationally matched controls on all the tasks proposed, validating the hypothesis that dyslexic adults have difficulties at the level of phonological representations. Palmer (2000) also focused on the phonological recoding deficit in dyslexic teenagers investigating the development of the phonological recoding and the central executive functioning, concluding that the deficient development of certain aspects of the central executive could be one of the causes of dyslexia.

At this point, what is important to underline is that all of these studies concentrated mostly on tasks such as, for example, non-word reading or single-word repetition without taking into account that dyslexic students in higher education may have compensated for or developed strategies to circumvent the difficulties they experienced in early life (McLoughlin 1997). At the stage of their education, the most salient features of their dyslexia may be evident in other areas as, for example taking lecture notes, writing essays, revising for examinations or comprehending large

quantities of complex texts. Simmons and Singleton (2000) administrated a study on reading comprehension abilities of dyslexic students in higher education arguing that previous studies on reading comprehension abilities of adult dyslexics have been impaired by the inappropriateness of the available assessment tools. Researchers have often used children's tests because of the lack of standardized tests suitable for adults. Reading comprehension tests designed for children also have poor ecological validity when used with adults. Their results showed that dyslexic individuals performed at a comparable level with non-dyslexic counterpart on literal questions on reading comprehension while they performed significantly poorer on the inferential questions. An impaired working memory and poor decoding automaticity appear to be plausible explanations for reading comprehension deficits found in the dyslexic adults; it is also possible that these subjects suffer from an additional problem such as a limited vocabulary or a general impairment in comprehending verbal information as a result of limited exposure to complex texts. Other explanations are possible: their metacognitive reading skills may be less well developed, resulting in inappropriate stategy choice.

Conclusions

As observed in this chapter, dyslexia is a wide disorder whose causes are still unclear. It involves a wide range of disabilities but, in its less severe manifestations, apparently it does not involve speech.

Chapter 2 On the theoretical presuppositions of the study

Introduction

In this chapter I am going to review the theories that constitute the basis of the study I admistered to adults dyslexics. My point of reference was Maria Vender's doctoral dissertation (2011) in which she administered some tests on several types of negation to a group of dyslexic children.

2.1 Negation

Negation is a highly specific linguistic tool, peculiar of the human language, which is employed to accomplish different tasks such as denying, contradicting, refusing concepts, correcting wrongly made inferences.

For its fundamental role in human language, negation has been extensively studied throughout the centuries. It has been a matter of research for philosophers as Plato and Aristotle and it has been dealt by classical logic. In the late eighties and nineties, research on negation has been linked to the study of presupposition and has gained increasing attention.

A large number of studies (Tettamanti et al. 2008, Kaup, Lüdtke & Zwaan 2006, Kaup et al. 2007) demonstrated that negative sentences require more time to be processed and led to higher error rates that the corresponding affirmative.

The contexts in which negative utterances occur are rather limited. Negative statements are uttered when the negated preposition is either explicitly mentioned before by one of the discourse partners or, at least, constitutes a plausible assumption in the respective context. Thus, negation is used to communicate deviations from what was previously expected or assumed (Givon 1978).

This leads to the prediction that negative sentences are more difficult to process mainly when presented outside of an adequate context in which the negated preposition is available prior to encountering the negation. This prediction was tested by Wason (1965) with respect to *non-linguistic* contexts. Participants were presented with pictures of eight circles, seven in one color and one in another color. They were asked to complete affirmative or negative sentence fragments. Negative fragments (e.g. *Circle N. 3 is not..*) took longer to complete than affirmative fragments (e.g. *Circle N. 3 is...*) but this difference was significantly smaller when the negative sentences referred to the circle with the exceptional color than when they referred to one of the seven other circles.

To our knolwdge this is the only study that experimentally investigated the effect of the linguistic context on the processing difficulty associated with negative sentences.

2.1.1 Negation in Italian

Negation in Italian shows different occurrences, that are conveyed through different linguistic means. These are:

- The negative particle non;
- Negative quantifiers as nessuno (nobody), niente (nothing), mai (never)...;
- Some higher-level constructs linked to the structure to deny;
- Lexemes with negative meaning.

The operation of presenting the state of art as non-existing in the extra-linguistic reality in the majority of cases is realised with the addition of the negative particle non, which presents an invariable form and in a preverbal position. In this position non is proclitic

and, in spite of this fact, it admits a contrasting accent when it is necessary to oppose negativity to non-negativity.
With the particle non, the adverb mica (< lat. Mīcam) can intensify the negation from the pragmatic point of view, rejecting implications or inferences advocated by the context (Cinque 1976) as in the case of the question "Hai capito? [Did you understand?]" to which one could answer:

Certo che ho capito: non sono mica stupido io [Sure I understood. I am not stupid.]

In fact in Italian the double negation non...mai has a negative value and occurs even with other adverbs:
Non è che io non abbia voglia di venire [it is not that I do not want to come]

Other elements, which do not operate on the verb phrase, can have the function of negation:

- Some indefinites adjectives and pronouns such as nessuno (nobody), niente/nulla (nothing), mai (never), that indicate the non-existence referring to general cathegories respectively animated being, inanimated being and time. Nessuno, niente e nulla can also be used as pronouns as in the case nessuno mi ha detto niente [nobody told me anything]; and nessuno can also be used with an adjectival function as in the cases da nessuna parte, in nessuna maniera;
- The conjunctions neanche, nemmeno, neppure that add a negative element to others already expressed in the context as in the case non mi piace il tennis e neanche (nemmeno, neppure) il calcio;
- Correlative conjunctions (né)...né that can coordinate elements with the same syntactical function: non li ho (né) visti né sentiti;

- The form with no is mainly used as an holophrastic answer to a polar question as in the case: “Piove?” “No” [“Does it rain?” “No, it doesn’t”] where the answer no is equivalent to an whole sentence as “Non piove” and, indeed, it represents in an absolute negative form the answer to the question contrasting to sì which represents the same content in a positive form.

2.2 The processing of negation

The processing of negation has been a matter of a considerable amount of research in the Sixties and in the seventies. In most of the studies conducted (Wason 1959, 1961; Carpenter&Just 1975) participants were asked to verify affirmative and negative sentences either against their background knowledge (Sentence-verification task), or against a picture (Picture-verification task). From the results, it clearly emerged that negative sentences were more difficult to process than their affirmative counterparts as shown by higher error rates or longer reaction times.

The most persuading hypothesis formulated to explain the higher processing difficulty of negation is one of a pragmatic nature, claiming that negative sentences are particularly difficult to process when they are used in an unsupportive context.

The basis of this orientation is Wason’s (1965) proposal, known as the hypothesis of the “Context plausible denial”. Observing the sentences reported below, Wason notes that (1b) seems odder than (1a).

1) A. The whale is not a fish.
   b. The whale is not a bird.

Even though both statements are negative and share the same truth value, (1b) takes longer to be processed and seems less appropriate. Wason focuses precisely on this

feeling of inappropriateness, noting that there is an association between the appropriateness of a negative sentence and the plausibility of its affirmative counterpart. In fact, it seems perfectly plausible to wonder whether a whale is a fish, whereas it would seem far strange to wonder whether it is a bird.

According to Wason, (1a) is pronounced in a supportive context, because there is an expectation to be denied (i.e. that the whale is a mammal). In this sense, negatives have the function to emphasize a fact that deviates from the expectations and therefore has to be negated. In this approach, the plausibility of a negative sentence is indissolubly connected to the presence of a prior statement that is to be denied. In other words, it is possible to say that negative statements presuppose the existence of an affirmative sentence that has to be denied.

A number of studies have provided results which corroborated this hypothesis, showing that negation is processed more easily and more rapidly when it is used to negate a preposition previously introduced in the context and when its affirmative counterpart is plausible. Interestingly, this tendency has been shown also by two- three- and four-year-old children who appear to be aware of the pragmatic requirements of negative sentences (De Villiers & Flusberg 1975). A similar proposal is made by Givón (1978), who argues that negative sentences require a particular pragmatic context within which they are processed to counter presuppositions held by the listener. This view is also shared by Horn (1989), who claims that the prototypical use of negation consists in denying a previously asserted preposition.

Jordan (1998) claims that negative clauses introduce two prepositions, namely the preposition itself plus its cancellation. Negation is, in fact, an affirmative with a negative operator added to it and that a negation is initially interpreted as an affirmation.

Since negative sentences are syntactically more demanding than affirmatives, and intriguing question concerns what brain mechanisms underlie our ability to represent

and understand the meaning of negative sentences. Many studies approached this issue by investigating the action-related language processing and the associated neural representations. For example, Carpenter et al. (1999) in a fMRI[13] study with a sentence-to-picture matching task found that subjects responded slower to negatives than to affirmatives and reported that negatives resulted in significantly more activation than affirmatives. Significantly higher activations in the left posterior temporal and bilateral posterior parietal lobes were found for negative sentences.

Hasegawa et al. (2002) used a probe-to-target matching task for a fMRI study. The behavioural results showed that negatives took longer time to be processed and induced more errors than affirmatives. In this study, it seems that negation elicited higher activations only in combination with increased extrinsic, non-linguistic task demands, such as the processing of visuo-spatial relations or of a second language at low proficiency.

Christensen (2009) investigated the neural correlates of the contrasts between affirmative and negative sentences using fMRI. This study focused on two other linguistic differences such as semantic differences in the direction of the entailment and the different amount of syntactic structure. In this view affirmative sentences should be upwards entailing: if a preposition about an element is true, the same preposition will also be true about the superset of the element. In the same way, negation is downward entailing: if a negated preposition is true, the same will hold for the subset. So, an

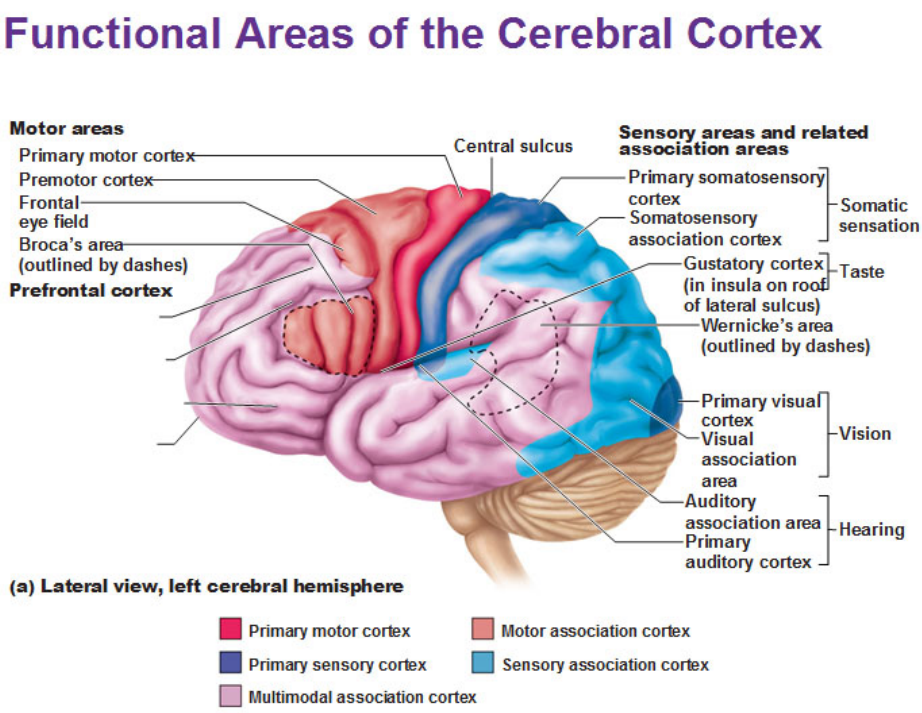
[13] Functional magnetic resonance imaging is a magnetic resonance procedure that measures brain activity by detecting associated changes in blood flow. This technique relies on the fact that cerebral blood flow and neural activation are coupled. When an area of the brain is in use, blood flow to that region also increases. The primary form of fMRI uses the blood-oxygen-level-dependent (BOLD) contrast. This is a type of specialized brain and body scan used to map neural activity in the brain or spinal cord of humans or animals by imaging the change in hemodynamic response related to energy use by brain cells. Since the early 1990s, fMRI has come to dominate brain mapping research because it does not require people to undergo shots, surgery, or to ingest substances, or be exposed to radiation (www.ndcn.ox.ac.uk Introduction to fMRI).

affirmative sentence involves more general semantic structure than a negative sentence.

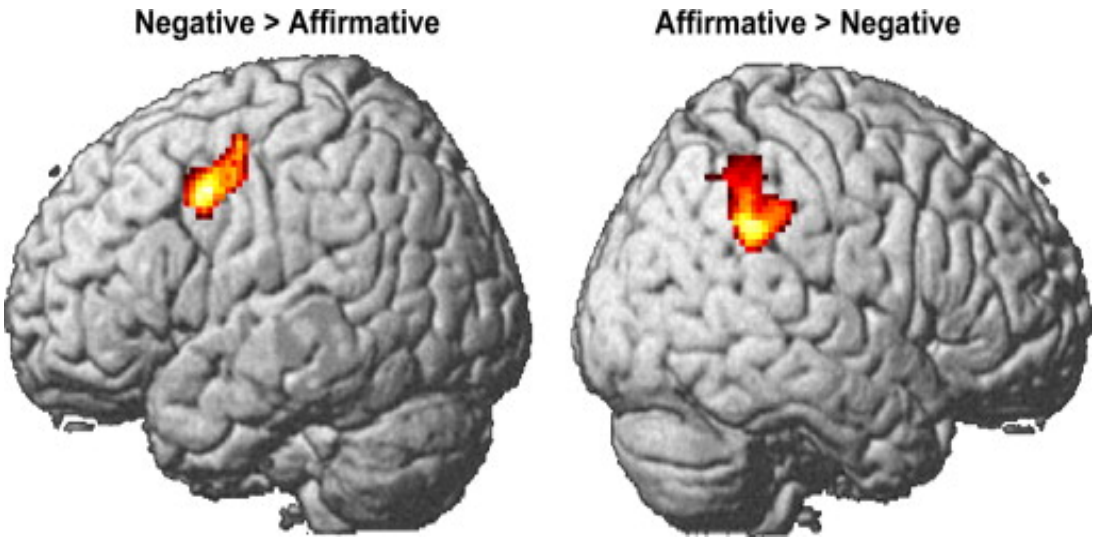
Tettamanti et al. (2008) in a fMRI study investigated if negation determines a reduced access to mental representations of negated concepts, anatomically distinct modulatory effects for concrete or abstract semantic content should be expected. Although this study represents a preliminary step toward the understanding of the neural mechanisms of sentential negation, the results are in line with the idea of a reduced access to the negated information.

Based on the fMRI studies on negation discussed so far, the following three cortical regions would be predicted to be involved in the contrast between negative and affirmative sentences:

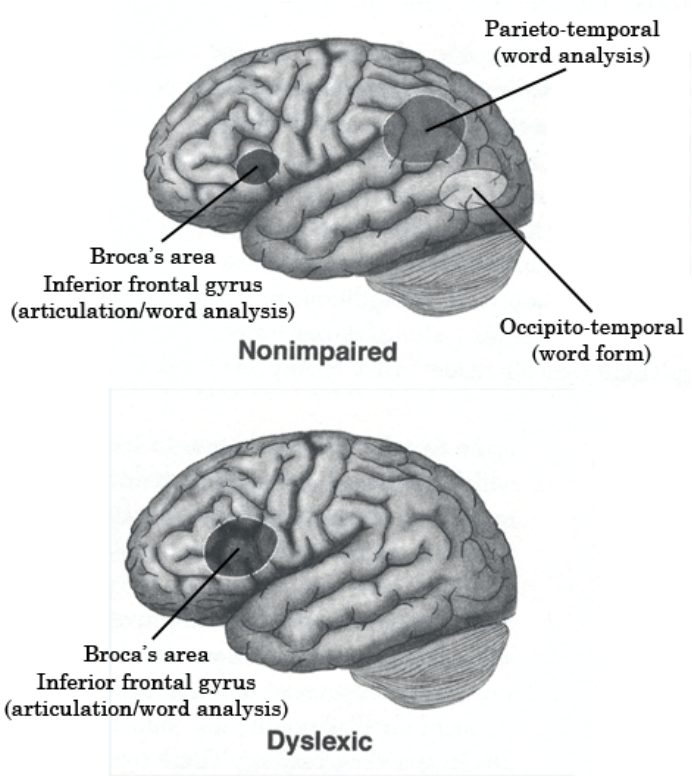
Left premotor cortex (BA 6) (Simos et al. 2000);



- Bilateral parietal cortex (possibly extending into the posterior temporal region)(Simos et al. 2000);



- Left inferior frontal gyrus (found to be recruited in tasks involving computation of various types of syntactic complexity)(Simos et al. 2000).



Other studies, as for example Sabisch et al. (2006), investigated auditory sentence comprehension and the differences in specific domains of prosody and syntax between dyslexics and control children through the use of the event-related brain potentials (ERPs)14. In the ERP, both dyslexics and control children showed a similar N400[15]

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[14] An event-related potential (ERP) is the direct result of a stereotyped electrophysiological response to a specific sensory, cognitive, or motor event stimulus. With this technique we can take raw EEG data and use it to investigate the cognitive process. The raw EEG recorded directly from a subject is a summation of all activity occuring at a given moment in time. Compared with behavioral procedures, ERPs provide a continuous measure of processing between a stimulus and a response, making it possible to determine which stage(s) are being affected by a specific experimental manipulation. Another advantage over behavioral measures is that they can provide a measure of processing of stimuli even when there is no behavioral change. However, because of the significantly small size of an ERP, it usually takes a large sample size to accurately measure it correctly(Brainlang.georgetown.edu).

component for the semantic violation and semantic integration processes. For the syntactic violation, control children showed a combined pattern with a late centro-parietal positivity (P600)[16]. Dyslexic children showed a different pattern characterized by an inital delayed left-lateralized anterior negativity, followed by a P600. The bilateral distribution in controls suggests an involvement of right hemispherically established prosodic processes in addition to the left hemisferically localised syntactic processes, supporting the view that prosodic information may be used to facilitate syntactic processing assuring normal comprehension. Whereas, for dyslexic children a left hemispheric distribution has been observed, suggesting that these children do not rely on information about the prosodic contour during auditory sentence comprehension much as controls do. These findings point toward a phonological impairment in dyslexics that might hamper the development of syntactic processes.

Georgiewa et al. (2002) in their study combined both techniques: the ERPs and the fMRI and focused on the difficulties in phonological processing, currently considered one of the major causes for dyslexia, in particular analysing the silent reading of words and pronounceable non-words. For what concerns fMRI, their study confirmed the results shown in other studies: a significant difference in the activation in the left frontal gyrus between dyslexics and control groups, resulting from a hyperactivation in the dyslexics.

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[15] The N400 is a component of time-locked EEG signals known as event-related potentials (ERP). It is a negative-going deflection that peaks around 400 milliseconds post-stimulus onset, although it can extend from 250-500 ms, and is typically maximal over centro-parietal electrode sites. The N400 is part of the normal brain response to words and other meaningful (or potentially meaningful) stimuli, including visual and auditory words, sign language signs, pictures, faces, environmental sounds, and smells (Sur and Sinha 2009).

[16] The P600 is a component of time-locked EEG signals known as event-related potentials (ERP). It is characterized as a positive-going deflection with an onset around 500 milliseconds after the stimulus that elicits it; it often reaches its peak around 600 milliseconds after presentation of the stimulus, and lasts several hundred milliseconds. It is thought to be elicited by hearing or reading grammatical errors and other syntactic anomalies. It is typically thought of as appearing mostly on centro-parietalelectrodes (i.e. over the posterior part of the center of the scalp), but a 2007 study using magnetoencephalography (MEG) speculates that the generators of the P600 in the posterior temporal lobe, behind Wernicke's area (Sur and Sinha 2009).

The ERP scalp distribution showed a significant distinction between the two groups concerning the topographic difference. In this case, both the fMRI and the ERP results support differences in phonological processing between dyslexics and normal-reading children.

Different types of negative sentences are represented in the mind and processed differently for example depending on whether they contain bipolar or contradictory predicates. Kaup, Zwaan & Lüdtke (2006,2007) argue that comprehending a negative sentence is a two-step process.

2.3 The Two-Step Simulation Hypothesis

The belief that negative sentences presuppose the existence of a prior statement which must be corrected is the central idea of the Two-Step Simulation Hypothesis proposed by Kaup, Zwaan & Lüdtke (2007).

This hypothesis rests upon the experiential view of language comprehension claiming that comprehending a text involves the construction of a mental representation of the described state of affairs, the so-called *situation model*. This hypothesis is supported by a large body of empirical evidence, suggesting that comprehenders mentally simulate the state of affairs which is described in the utterances in a way that is similar to directly experiencing it. Neuroscience studies have demonstrated that there is a significant overlap between the mental subsystems involved in the representation of linguistically conveyed information and those used to perceive or enact the same situations (Pulvemüller 2002). Moreover, behavioural experiments have shown that non-linguistic cognitive processes such as perception, action planning or imagery depend on the same mental subsystems involved in the creation of representations used for language comprehension (Kaup et al. 2007). However, the existence of linguistic operators such

as negation poses a potential problem for this view, since they do not seem to have a direct equivalent in experience. Therefore, researchers tried to answer the question of how negative text information is represented.

First, it has been proposed that negated information is simply absent from the experiential representation of the state of affairs, but this hypothesis has been discarded. In other cases, however, the representation of a negated entity can be obtained representing its affirmative counterpart. To solve this impasse, Kaup and colleagues resort to an idea very similar to the pragmatic considerations about negation proposed by Wason (1965), Givón (1978) and Horn (1989), who argue that negative statements are generally uttered to deny a corresponding positive presupposition attributed to the listener. Kaup et al. observe that negation seems to be used to communicate to the listener a deviation from her expectancies. For instance, this example:

When she entered the room, Lisa noticed that the television was not off.

can be uttered felicitously only in a context in which the television should have been turned off. Intuitively, thus, it seems that negation invites to delete a previously built *expected state of affairs* (e.g. the television being turned off), replacing it with the representation of the actual state of affairs (e.g. the television being turned on). Comparing these two simulations allow the comprehender to determine what the sentence is about.

According to the Two-Step Simulation Hypothesis, the comprehension of negation involves:

i. The retrieval (or the construction, e.g. in unsupportive contexts) of a simulation of the expected state of affairs, which corresponds to the state of affairs that is being negated in the sentence;
ii. The construction of a simulation of the actual state of affairs.

Two cases can be distinguished:

- when the negated state of affairs is already present in the discourse representation before encountering negation, the comprehender must simply correct the expectations by simulating the actual state of affairs;
- when the negated state of affairs is not present in the discourse context, e.g. when the sentence is uttered out of the blue, the comprehender must construct a mental simulation of the expected state of affairs and then turn towards representing the actual state of affairs.

2.4 The model of Sentence-Picture Match processing for negative sentences

A number of experimental protocols have demonstrated that processing difficulties arise when subjects are asked to interpret negation. The tasks used to test the subjects' competence were mainly sentence-picture verification tasks, where participants had to verify sentences against pictures. The results showed a significant effect of negation, with negative sentences taking longer to process than their affirmative counterpart. Moreover, a significant effect of truth has also been found, with true negative sentences being the most difficult ones to process, with the highest error rates. This result was quite surprising, since it was expected that false affirmatives were harder than true affirmatives and that false negatives were harder than true negatives. Instead, an asymmetry was found between affirmative and negative sentences, with the following ranking:

True affirmatives > false affirmatives > false negatives > true negatives

For this study, I have used the model developed by Maria Vender for her doctoral dissertation. She developed a model that can account for the greater processing difficulties of:

i. negative sentences in comparison to affirmative sentences;
ii. false affirmatives in comparison to true affirmatives;
iii. true negatives in comparison to false negatives.

In her experimental protocol, Vender proposed that subjects must create a mental simulation of the expected state of affairs and compare it to the simulation of the actual

state of affairs. This operation is remarkably demanding in terms of working memory resources and is responsible for the higher difficulty of negative sentences.
Moreover, Vender adopted the Sentence-Picture Verification Task because in this type of task subjects have to cope with an additional difficulty: thay have to compare the representation of a sentence to that of a picture in order to decide if the sentence correctly decribes what happens in the picture. Vender proposed that the picture provided in the experiment can be used to create the mental simulation: if the picture does not provide the subject with a representation of what the sentence is about (e.g. "It is not true that the dots are black" against a picture of red dots), the subject has to correct this mismatch by creating a representation of the sentence which can be compared against the picture. On the other hand, when the picture and sentence match, the subject's task is facilitated. This difference can explain the longer latencies reported for false affirmatives in comparison to true affirmatives and for true affirmatives and for true negatives in comparison to false negatives. In fact, in the "false affirmative" condition as well as in the "true negative" condition there is arguably a mismatch between the sentence and the picture which are considered responsible for their higher complexity of the sentence-types at stake.
According to the Model of Sentence-Picture match processing for negative sentences proposed by Vender, three main steps are required to evaluate target sentences against pictures:

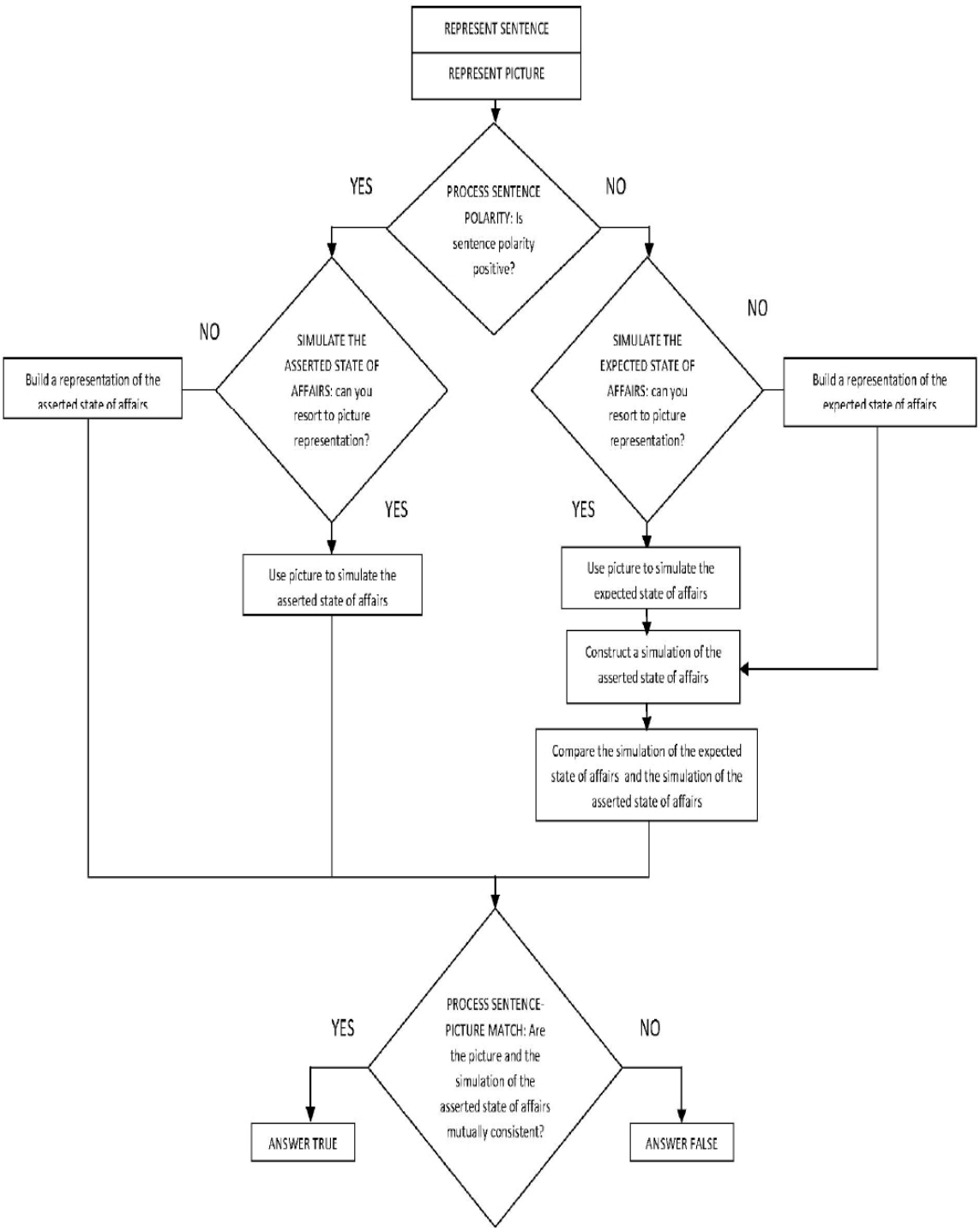
i. Sentence-polarity processing: the subject has to process sentence polarity. If the polarity is positive, he/she can represent the actual state of affairs, but if it is negative, he/she has to simulate first the expected state of affairs and then the actual state of affairs. Arguably, negative sentences are predicted to be more

difficult than affirmative sentences, sinc they require the construction of two different representations, in accordance with the *Two-Step simulation hypothesis*;

ii. Simulation of the asserted state of affairs: after polarity has been processed, the subject has to create the representation of the asserted state of affairs. When possible, the subject can resort to the picture to simulate the state of affairs. Otherwise, if the picture does not match with the event described in the target sentence, an additional step is required, since the subject needs to build a simulation by herself. The prediction is thus that a greater effort is required when the subject cannot resort to the picture in order to represent the state of affairs;

iii. Sentence-Picture Match Processing: in the final passage, the subject has to verify if the picture and the representation of the asserted state of affairs are mutually consistent. If they are, he/she can aswer “true”, otherwise, he/she will aswer “false”.

This is a representation of the model of verification for negative sentences proposed by Vender:


REPRESENT SENTENCE
REPRESENT PICTURE
PROCESS SENTENCE POLARITY: Is sentence polarity positive?
YES
NO
SIMULATE THE ASSERTED STATE OF AFFAIRS: can you resort to picture representation?
NO
Build a representation of the asserted state of affairs
YES
Use picture to simulate the asserted state of affairs
SIMULATE THE EXPECTED STATE OF AFFAIRS: can you resort to picture representation?
NO
Build a representation of the expected state of affairs
YES
Use picture to simulate the expected state of affairs
Construct a simulation of the asserted state of affairs
Compare the simulation of the expected state of affairs and the simulation of the asserted state of affairs
PROCESS SENTENCE-PICTURE MATCH: Are the picture and the simulation of the asserted state of affairs mutually consistent?
YES
NO
ANSWER TRUE
ANSWER FALSE

Let us see how this model works, examining each condition. Suppose that the subject is presented with the target sentence and afterwards with a picture depicting Cinderella who is combing her hair, like the one reported below.

i. True affirmative: the target sentence is“Cinderella is combing her hair”. According to the model, the subject has first to consider sentence polarity. Since it is positive, she can move to the second step, concerning the simulation of the asserted state of affairs. In this case, the picture provides the subject with a representation of what the sentence is source of help to simulate the asserted state of affairs. Finally, he/she has to compare the picture and the simulation: given that they are mutually consistent, the subject can answer “true”;

ii. False affirmative: the target sentence is “Cinderella is cleaning the house”. Again, sentence polarity is positive and the subject needs to represent the asserted state of affairs. In this case, however, the picture does not help the subject to build a

representation of what the sentence is about and he/she must construct a mental representation of Cinderella cleaning the house. Arguably, this causes an extra-effort that may be taken as responsible for the lonegr latencies required by false affirmatives in comparison to true affirmatives. At last, the subject has to match the picture and the simulation of the asserted state of affairs: since they are not mutually consistent, he/she answers “false”;

iii. False negative: the target sentence is “Cinderella is not combing her hair”. In this case, polarity is negative and thus the subject has to simulate first the expected state of affairs (e.g. Cinderella who is combing her hair) and afterwards the asserted state of affairs (e.g. Cinderella who is doing something else, possibly unspecified), consistently with the Two-Step Simulatio Hypothesis. This additional passage results in the higher processing load required by negative sentences in comparison to affirmative sentences. In order to represent the expected state of affairs, the subject can resort to the picture, since it actually offers a representation of what the sentence is about. Finally, he/she has to compare the simulation of the actual state of affairs with the representation in the picture. Since they are not mutually consistent, the sentence is judged “false”;

iv. True negative: the target sentence is “Cinderella is not cleaning the house”. Also in this case, the polarity of the sentence is negative, requiring the simaulation of both the expected state of affairs (e.g. Cinderella who is cleaning the house) and the asseted state of affairs (Cinderella who is doing something else, possibly unspecified). However, the subject cannot resort to the picture to create the two simulations, she has rather to mentelly simulate them. Finally, since the simulation of the asserted state of affairs and picture representation are mutually consistent,

the target sentence is judged “true”. Summarizing, the greatest difficulty found in the processing of true negative sentences is due to two distinct factors: firstly, to the negative polarity of the sentence, requiring the subject to construct and compare two representations, and secondly to the impossibility for the subject to use the picture as a source of help in order to generate the simulation of the state of affairs at stake. This second factor is responsible for the longer latencies found with true negative sentences in comparison to false negative sentences.

In conclusion, this model of verification can account for the greater difficulty found with negative sentences in comparison to affirmative sentences, assuming that the subjects are forced to simulate two representations when processing a negative sentence, both for the expected and the actual state of affairs. It can also account for the higher complexity of false affirmatives in comparison to true affirmatives and of true negative in comparison to false negatives, arguing that false affirmatives and true negatives require the subject to create *ex novo* a representation of what the sentence is about, without using the picture representation as a source of help.

2.5 Maria Vender’s experimental protocol

In her doctoral dissertation, Maria Vender investigated how dyslexic children compute negative sentences in sentence-picture verification tasks in comparison to age-matched typically developing children.

Her experimental protocol was composed by four different tasks testing respectively:

i. The computation of negative sentences;
ii. The computation of negative passive sentences;
iii. The computation of sentences containing negative quantifiers;

iv. The computation of sentences with negative concord.

In her study she considered both error rates and response times, taking into account that dyslexic children manifested greater difficulties in comparison to control children in all tasks, as demonstrated by higher error rates and slower response times.

To interpret the results, she adopts the framework outlined by Kaup et al. (2007), according to which negation communicates a deviation from expectancies. Negation invites the comprehender to retrieve, or, if necessary to build a simulation of the expected state of affairs, which has the role to represent the affirmative counterpart of the negative sentence.

Her experimental hypothesis was that this operation is remarkably expensive in terms of processing resources. Therefore, assuming that dyslexic children display a working memory limitation, higher error

rates are expected.

Her experiment was conducted on a group of 17 dyslexic children (mean age 9;9), all native speakers of Italian selected according to the absence of:

i. sensorial diseases;
ii. neurological diseases or genetic pathologies;
iii. psychopathological diseases;
iv. IQ > 80;
v. Fluent and correct reading and writing abilities under 2 SD.

Their performance has been compared to 17 age-matched (9;8) typically developing children.

A sentence-picture verification task was administered. As in Carpenter and Just (1975), subjects were presented with a picture depicting a situation. The experimenter introduced them with a puppet, Little Red Riding Hood, who had the task to explain

what was happening in the picture. The subject was told that Little Red Riding Hood was not always able to describe correctly what was happening in the story. Therefore, the subject's task was to decide if Little Red Riding Hood described the picture correctly or not by pressing a smiling face for the right answer and a crying face for the wrong answer. Response times were measured using the SuperLab software, starting from the moment when the experimenter uttered the target sentence up to the moment when the subject pressed the button to give the answer.

The task involved 12 experimental items, intertwined with 6 fillers. The subjects were presented with a picture describing the character reading a newspaper as in the picture below. There were four experimental conditions:

i. Condition A: True Negative sentence with internal negation:

La gallina non sta facendo la spesa.

"The hen is not going shopping."

ii. Condition B: False Negative sentence with internal negation:

La gallina non sta leggendo il giornale.

"The hen is not reading the newspaper."

iii. Condition C: True negative sentence with external negation:

Non è vero che la gallina sta facendo la spesa.

"It is not true that the hen is going shopping."

iv. Condition D: False negative with external negation

Non è vero che la gallina sta leggendo il giornale.

"It is not true that the hen is reading the newspaper."

Vender analysed the results and found that dyslexic children performed more poorly than age-matched typically developing children when asked to interpret negative sentences and commit significantly more errors in all conditions in comparison to control children, even though no differences has been found for what concerns reaction times.

She considered her results consistent to the Two-Step Simulation Hypothesis assuming that negation generally expresses a deviation from expectancies. In this perspective, what renders a negative sentence difficult to process in comparison to affirmative sentences is the actual state of affairs. The task proposed here, is further complicated by the request to verify the target sentence against a picture.

As predicted by the model presented in Section 2.4, negative true sentence are more difficult to process than false sentences, as shown by significantly higher error-rates. This result seems to be strictly connected to the fact that in the “true” conditions the picture does not provide the comprehender with a representation of the event described in the sentence. As a consequence, the subject must create by him/herself a mental representation of the sentenceto be compared to the picture. This operation is arguably expensive in terms of processing resources and it contributes to make true negative sentences more difficult than false negatives sentences.

For what concerns working memory, the results show that this operation has a visible cost only for dyslexics: in fact, they cannot cope with the task because of their poor working memory skills.

So, these results seem to corroborate the working memory deficit hypothesis, claiming that dyslexia is associated with a working memory limitation, causing dyslexics’ difficulties in processing complex sentences.

Conclusions

In this chapter I overviewed the theories that lay behind my experiment, describing Maria Vender's experimental protocol and her results on children.

Chapter 3 The study

Introduction

This chapter accurately describes the study and its results. In particular, the predictions, the participants, the materials constructed for the experiment, methods of administration of the experiment. There will also be an analysis of the results and a further discussion will be presented.

3.1 Predictions

On the basis of existing research, it is possible to formulate these predictions:

- Verify if the problems in the comprehension of negative clauses introduced by the negative particle *non* persist among dyslexic adults;
- Both groups should perform better with true affirmative clauses;
- Dyslexics should perform poorly with false negative clauses showing a higher error rate and slower reaction times;
- Adult dyslexics' performances in the computation of negative sentences should differ in comparison to age-matched adults;
- If dyslexics suffer from a working memory impairment, they are expected to underperform in comparison to the control group.

3.2 Participants

The experimental group is composed by 5 dyslexic adults (4 female and 1 male) aged between 21 and 25 years (average 22;5) recruited through the disability office of the University Ca' Foscari of Venice and the University of Verona (See Table 1). Their performance will be compared with 5 adults (3 female and 2 male) aged between 21 and 23 years (average 22;2) of comparable education level (See Table 2). Participants were all native monolingual speakers of Italian, with no history of neurological or psychiatric disorders.

Table 1 Dyslexic participants

ID	Age
Sg1	21;5
Sg2	25;1
Sg3	20;5
Sg4	23;9
Sg5	21;6

Table 2 Control group

ID	Age
Ct1	23;3
Ct2	21;7
Ct3	21;6
Ct4	23;4
Ct5	21;2

3.3 Materials

The experimental task was a *Sentence-Picture Evaluation Task* similar to the one used by Vender (2011) and was composed by 120 stimuli. Each stimulus was composed by a pre-recorded sentence and a picture. The subjects listened to a sentence for 2-3s each, followed by a picture (as in Picture 1) for 500ms depicting 2 characters performing an action[17]. Then, the subject is asked to answer true or false by pressing the 1 or 2[18] on the

[17] The condition in which both caracthers are performing an action was preferable to that in which only one of the two was acting because, in some cases, this would induce the subject to look only at one character . For example, hearing a sentence as "Marge non sta lavando i panni"[Marge is washing clothes] and seeing a picture

keyboard. There will be 4 different experimental conditions (30 stimuli for each condition):

- False affirmatives: the subject has to compare the sentence “Homer sta lavando i panni” [Homer is washing clothes] to a picture depicting Homer who is eating a sandwich. The correct answer, in this case is false because the sentence does not correctly describe the picture;
- True affirmatives: the subject has to compare the sentence “Marge sta lavando i panni” [Marge is washing clothes] to a picture depicting Marge who is washing clothes. The correct answer, in this case, is true because the sentence correctly describes the picture;
- False negatives: the subject has to compare the sentence “Marge non sta lavando i panni” [Marge is not washing clothes] to a picture depicting Marge who is washing clothes. The correct answer, in this case, is false because the sentence does not correctly describes the picture;
- True negatives: the subject has to compare the sentence “Homer non sta lavando i panni” to a picture describing Homer who is eating a sandwich. The correct answer, in this case, is true because the sentence correctly describes the picture.

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in which Marge is not acting but the other carachter is washing clothes, would encourage the subject to look only at Marge without taking into account the other one.

[18] To facilitate all the subjects involved in the study, the keys were made recognisable by putting a green V on 1 to specify the key to press to give a positive answer, and by putting a red F on 2 to give a negative answer.

Picture 1 Example of a picture correspondent to the sentence “Marge sta lavando i panni” [Marge is washing clothes]

Given these 4 conditions, it is possible to argue that with false affirmatives and false negatives the sentence is not congruent with the picture shown, whereas with true affirmatives and true negatives the picture shown is congruent with the sentence heard. This experiment stemmed from a wider study promoted by Maria Scappini of the University of Verona for her Doctoral Dissertation, in which she planned to administer an ERP study[19] on some dyslexic children between 9 and 11 years old.

I made an internship of 150 hours at the University of Verona and I collaborated with Maria Scappini in the preliminary phases of the test in which we selected and improved

[19] This study wants to verify and corroborate the hypothesis formulated by Fiorin (2010) and Vender (2011) who highlighted the presence in dyslexic children of deficits in oral comprehension. Lütdke et al. (2008) collected electrophysiological data by applying an ERP protocol on processing of negative sentences on normal German subjects and Herbert and Kübler (2011) whose results showed a late positivity effect (a peak of positive intensity identifiable at 550 ms after the presentation of the stimulus) that would correspond to the moment in which negation is re-integrated in the representation of the situation (taking into account Kaup et al. 2007 with the Two Step simulation hypothesis), and the subject begins to build up a representation of the meaning actuallt asserted.

the quality of audio files through Audacity[20], segmented them using Praat[21] while for the pictures we used Gimp[22]. Before submitting the test to the dyslexic subjects, we went into two primary schools (Scuola Primaria "C. Collodi" in Isola della Scala (Verona) and Scuola Primaria "A. Cesari" in San Giovanni Lupatoto (Verona)) in order to calibrate the test among 9 year-old children . Initially, the test runned continuously, that is, the subject should answer in a given time because otherwise the test would propose the following stimulus but we realized that this solution involved a great fatigue for the subjects. We tested 20 children and found the right combination between audio file, picture and response time.

The experiment is administered through E-Prime[23]. Before testing there is a phase of familiarization in which the subject is presented to all the characters of the test. The aim is to understand if the participant is familiar with them. The carachters were chosen according to the average cartoons knowledge of 9-year-old children.

The subject sits in front of a laptop, watching the white screen. He/she was asked to listen carefully to a recorded sentence and then to look at a picture. Then the participant is asked to answer true or false by pressing 1 or 2 on the keyboard establishing a connection between what previously heard to what seen in the picture. The following stimulus would come only after the subjects' answer. No feedback of the response was given. The pairs of stimuli were in random order. The test began with 8 trial sentences. Every 30 stimuli a break was scheduled.

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[20] Audacity is a free digital audio editor and recording application for multiple sources. It can also be used for post-processing of all types, including podcasts by adding effects such as normalisation, trimming and fading in and out.

[21] Praat is a free scientific computer software package for the analysis of speech in phonetics.

[22] Gimp i san image retouching and editing tools which are also used for free-form drawing, resizing, cropping, photo-montages and converting between different image formats.

[23] E-Prime is the most used suite of applications for computerized experiment design, data collection and analysis providing millisecond precision timing.

3.4 Quantitative analisys

The dyslexics' performance does not differ from the control group as it is possible to notice in Table 3.

Table 3 Percentages of correct answers

	False affirmatives	True affirmatives	False negatives	True negatives
Sg1	96%	93%	83%	83%
Sg2	100%	100%	96%	93%
Sg3	100%	100%	93%	96%
Sg4	90%	96%	90%	93%
Sg5	93%	100%	86%	93%
Average Dyslexics	96%	98%	90%	92%
Ct1	90%	96%	96%	96%
Ct2	96%	86%	93%	100%
Ct3	96%	100%	96%	96%
Ct4	100%	96%	96%	100%
Ct5	100%	100%	100%	100%
Average Control Group	96%	96%	96%	98%

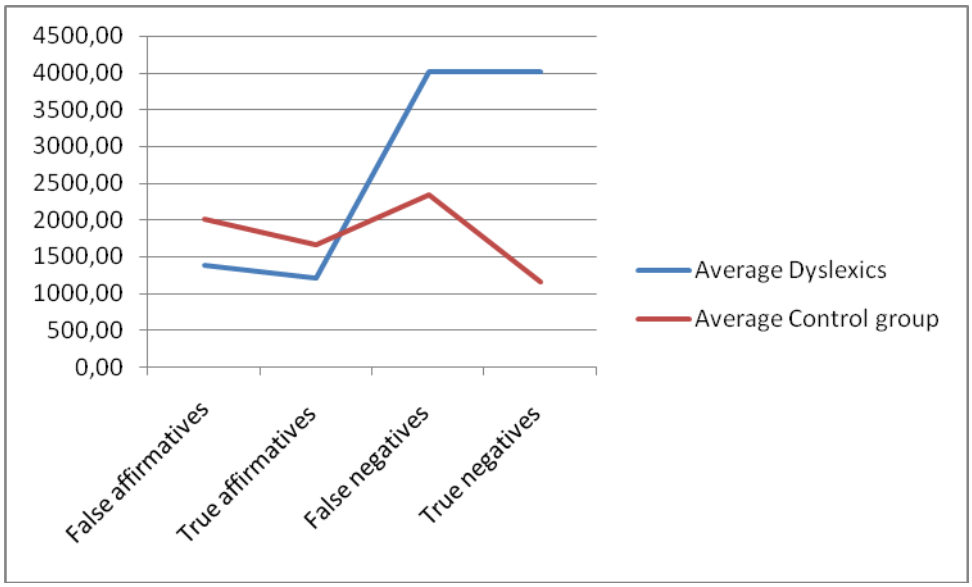
Dyslexics, however, also show a low percentage of correct answers with false negative clauses and with true negative in contrast with the performance of the control group. For what concerns the control group, the only data that have to be underlined is the rate of correct anwers with true affirmative clauses which is in contrast with the dyslexics' performance.

3.5 Qualitative analysis

Table 4 Average reaction time for uncorrect answers

	False affirmatives	True affirmatives	False negatives	True negatives
Sg1	3642,00	3879,50	5157,40	6347,40
Sg2	0,00	0,00	5578,00	5712,50
Sg3	0,00	0,00	3033,50	1859,00
Sg4	1411,67	2173,00	1816,00	3122,00
Sg5	1832,50	0,00	4455,00	3028,00
Average Dyslexics	1377,23	1210,50	4007,98	4013,78
Ct1	949,33	1207,00	793,00	2093,00
Ct2	1315,00	5465,75	3450,00	0,00
Ct3	7771,00	0,00	4567,00	3704,00
Ct4	0,00	1600,00	2863,00	0,00
Ct5	0,00	0,00	0,00	0,00
Average Control group	2007,07	1654,55	2334,60	1159,40

Graph 1 Average reaction time for uncorrect answers



Analysing Table 4 and Graph 1, it is possible to notice that dyslexics show slower reaction times with false negatives and with true negatives (average 4s) in contrast with the control group performances that settle between 1 and 2 s.

Dyslexics seem to perform well with false affirmatives and true affirmatives recording reaction times lower than 1,5s whereas the reaction times of the control group are slower, between 1,6 and 2s.

As Graph 1 confirms, dyslexics' reaction times with false negatives and with true negatives increasing up to 4s, whereas the reaction time of the control group increases with false negatives, decreasing with true negatives. The reaction times of both groups decrease with true affirmative sentences.

To sum up, for what concerns reaction times for uncorrect answers it is possible to argue that they all are standard reaction times ranging between 1,1 and 2,3s for both populations. The exceptions to the standards are the dyslexics' performances with false negatives and true negatives with slower reaction times ranging around 4s each.

Table 5 Average reaction times for correct answers

	False affirmatives	True affirmatives	False negatives	True negatives
Sg1	5337,21	3097,75	4175,12	4048,32
Sg2	3966,23	3036,70	3239,72	3361,11
Sg3	1460,40	1229,40	1642,25	1887,83
Sg4	2902,59	1806,69	2921,74	2437,25
Sg5	2132,25	1613,30	2165,69	2556,32
Average Dyslexics	3159,74	2156,77	2828,90	2858,17
Ct1	1391,56	1080,48	1543,48	1571,76
Ct2	1587,07	1789,38	2108,71	2028,90
Ct3	1932,66	2050,20	2421,72	2381,17
Ct4	1838,07	1577,28	1710,31	1796,80
Ct5	2849,13	2415,60	4553,97	3232,77
Average Control Group	1919,70	1782,59	2467,64	2202,28

Graph 2 Average reaction times for correct answers

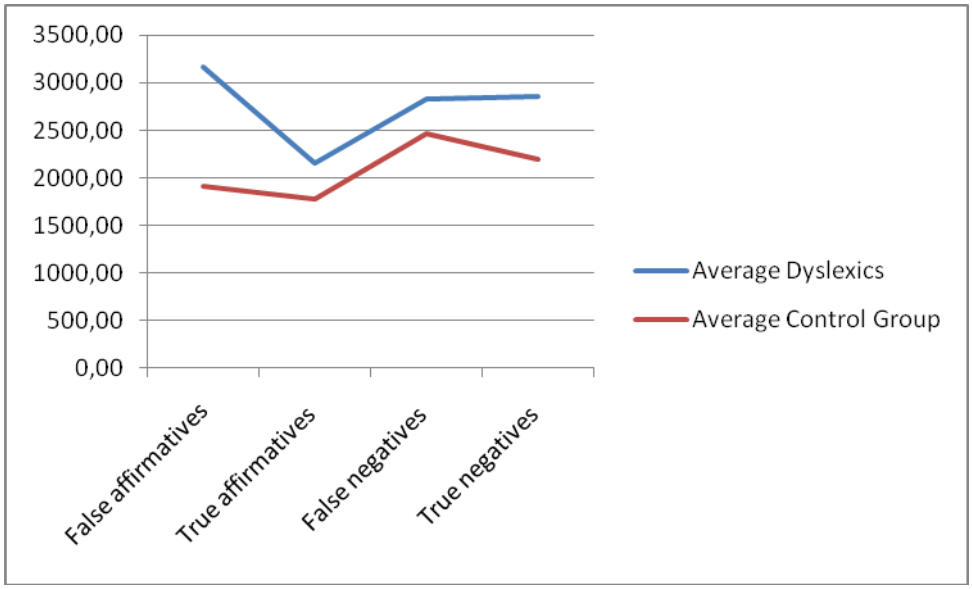
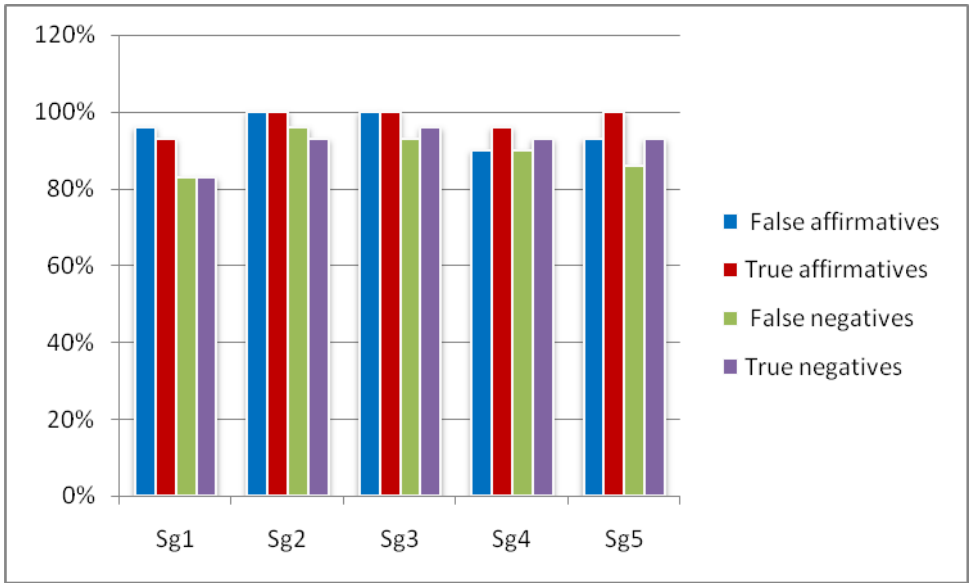


Table 5 and Graph 2 can account for the average reaction times for correct answers. It is possible to observe that in all 4 types of negative sentences proposed in the test, dyslexics show slower response times ranging between 2,1 and 3,1 s whereas reaction times of the control group range between 1,7 and 2,4s.

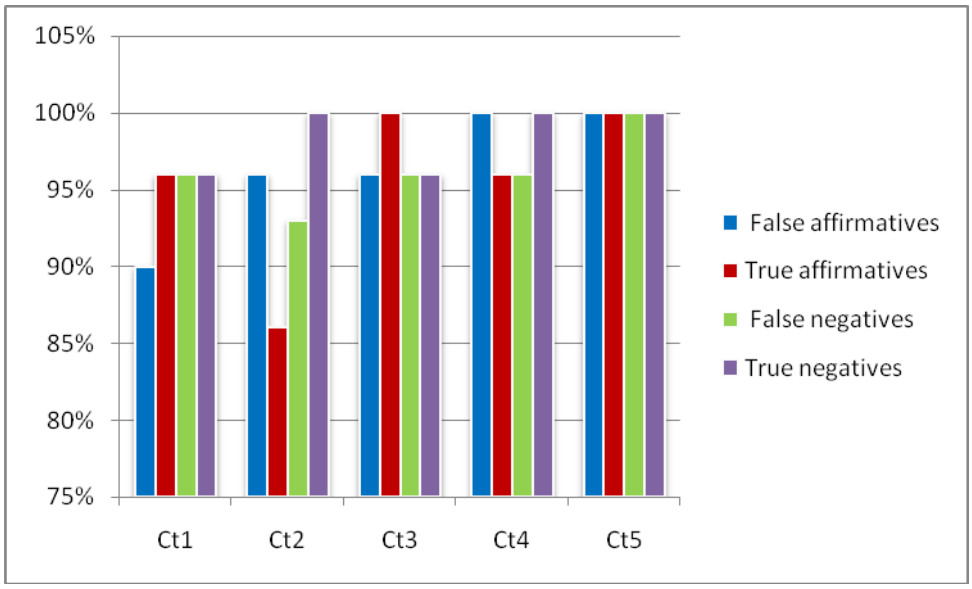
Graph 2 shows that reaction times of both groups decrease, becoming faster, with true affirmatives and increase, becoming slower, with false negatives.

It is easy to observe that even when dyslexics answer correctly to the stimuli proposed, their answers are far slower than the average.

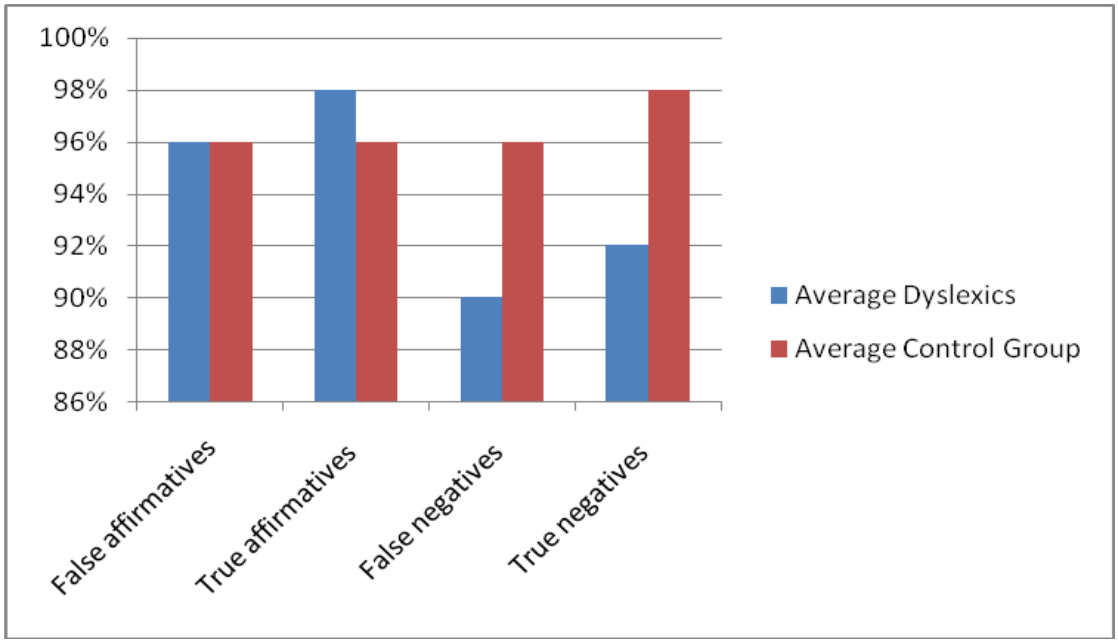
Graph 3 Percentages of corect answers (Dyslexics)



Graph 4 Percentages of correct answers (Control group)



Graph 5 Average percentages of correct answers



Graph 5 shows the average percentages of correct answers for both groups that reveal an equal percentage of 96% only with false affirmative clauses.

Dyslexics' rates of correct answers decrease with true negatives remaining around 92% against the 98% of the control group. The percentage of 90% with false negatives confirm that dyslexics have serious difficulties in coping with this type of sentence, especially if their performance is compared to the control group (98%).

For what concerns the control group, the rate of correct answers 96% with true affirmatives, that are supposed to be the easiest type of sentence to comprehend, is lower than dyslexics' (98%).

3.6 Statistical analysis

For this analysis 2 ANOVA mixed analysis with 2 factors within-subject Negation (affirmative and negative) and Congruency (true, false) have been made: one for the accuracy and on reaction times for correct answers. Also a between-subject factor for the group has been made.

3.6.1 Accuracy analysis

For what concerns accuracy there are only two aspects to take into account: the effect of negation and the effect of negation within the group. For negation, results show that the performances of the two groups are slightly different: $F(1,8)=5545$, $p < 0.05$. As it is predictable, these are more accurate with positive sentences (See Table 1 for more detailed results).

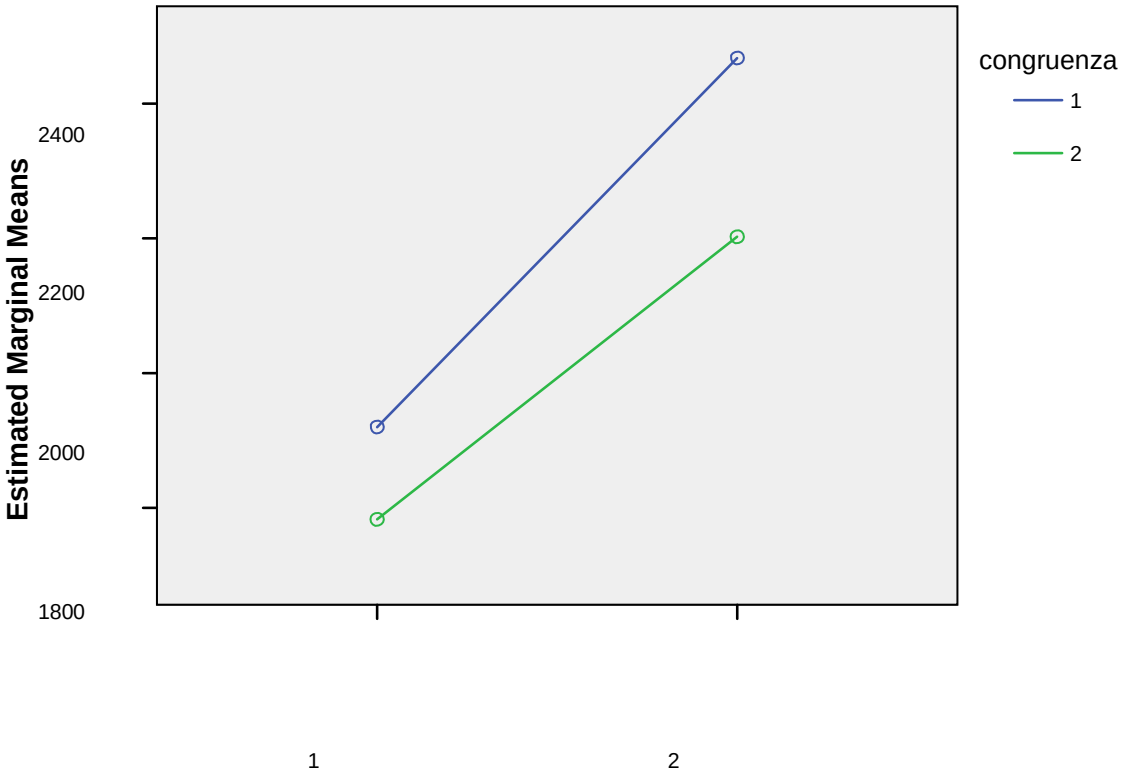
Table 1. Negation

negazione	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	96.400	1.108	93.844	98.956
2	93.950	1.129	91.346	96.554

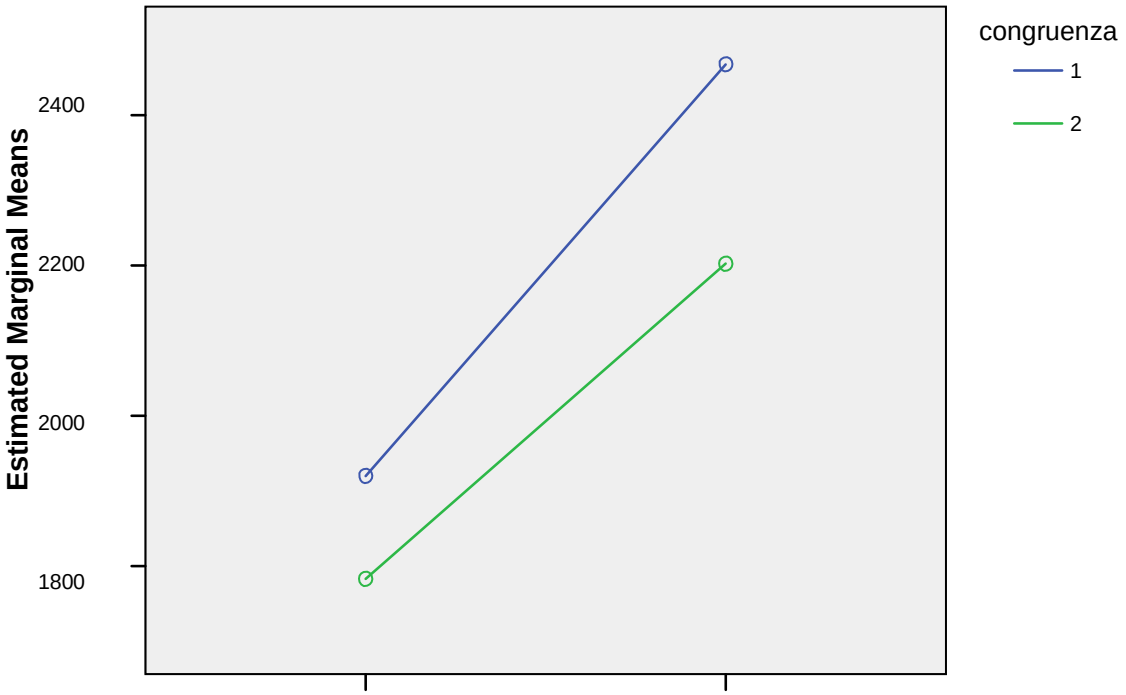
Table 2. Group Negation

gruppo	negazione	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	96.800	1.568	93.185	100.415
	2	90.600	1.597	86.918	94.282
2	1	96.000	1.568	92.385	99.615
	2	97.300	1.597	93.618	100.982

Graph 6 Dyslexics



Graph 7 Control group



As we can see from Graph 6, where in the x-axis 1 is affirmative and 2 is negative and the blue line stands for true and the green line for false, dyslexics show a higher accuracy with affirmative sentences and a lower value of accuracy with false clauses, both true negatives and false negatives (see also Table 2). Graph 7 shows that the accuracy of the control group is higher with true negative clauses and lower with true affirmatives while it is constant when they deal with false clauses.

3.6.2 Reaction times analysis

The statistical analysis of reaction times for correct answers seems to show more significant results. For what concerns negation $F(1,8) = 7.229$, $p < 0.05$. Another significant aspects are congruency F (1,8) =5894, p 0.041 and negation with congruency F (1,8) = 6.021, p 0.040.

Table 3. Negation

negazione	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2254.698	287.918	1590.758	2918.637
2	2589.247	289.096	1922.591	3255.903

Table 4. Congruency

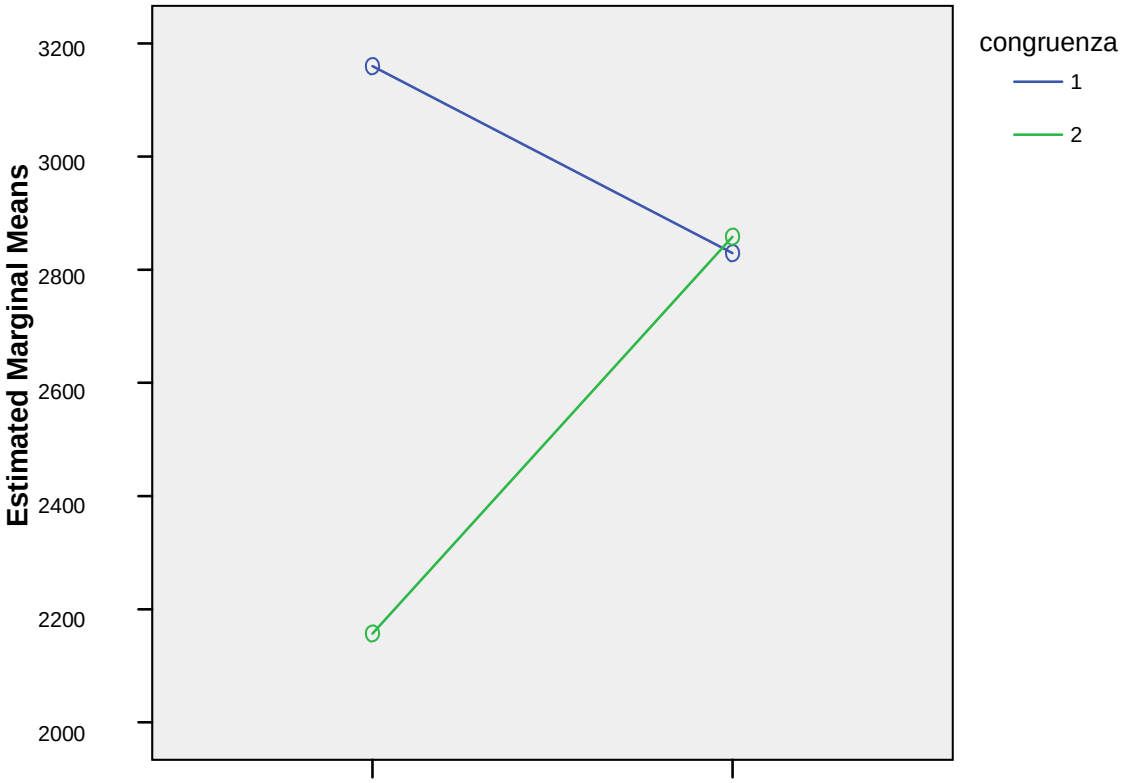
congruenza	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2593.994	342.326	1804.589	3383.399
2	2249.951	227.127	1726.196	2773.705

Table 5. Negation and congruency

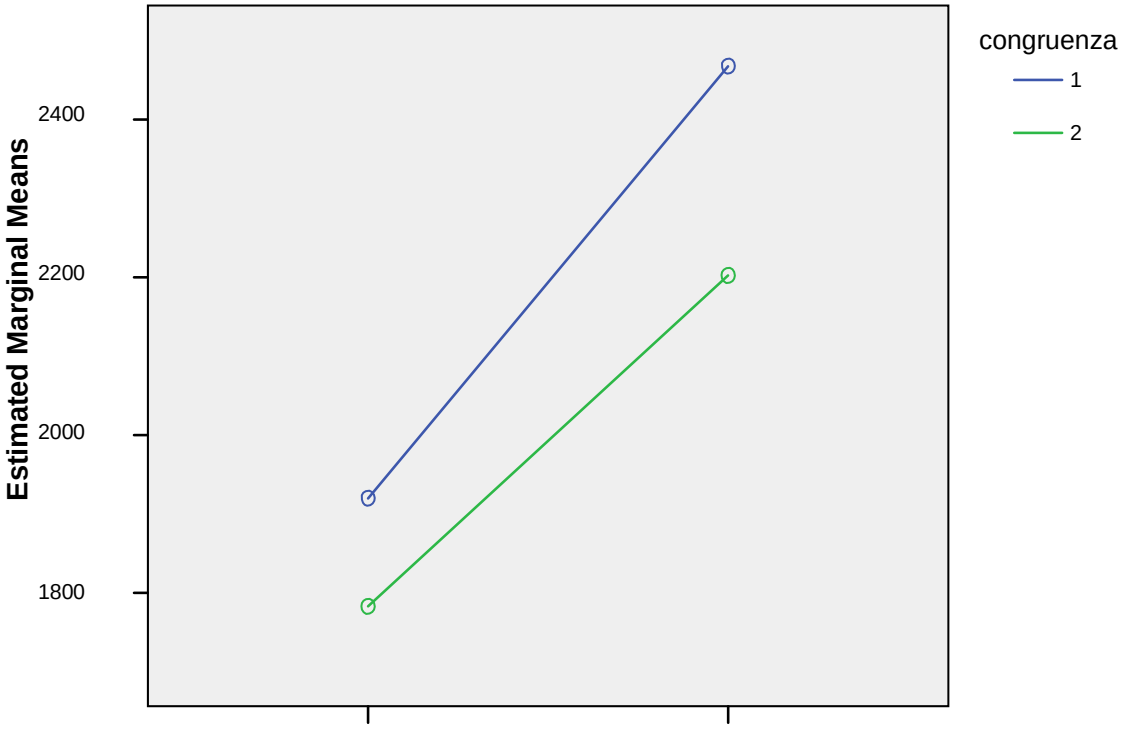
negazione	congruenza	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	2539.717	365.063	1697.881	3381.553
	2	1969.678	222.068	1457.589	2481.767
2	1	2648.271	349.088	1843.272	3453.270
	2	2530.223	238.883	1979.359	3081.087

As we can see from Graph 8 dyslexics have very slow response times for both types of negative clauses. For what concerns true affirmative clauses, their response times are as fast as the control group while, for false affirmatives, are the slowest between affirmatives. For what concerns Graph 9, the control group show faster response times for affirmative clauses (both true and false). Their response times are slower with negative clauses even if their reaction times are faster for true negatives.

Graph 8 Dyslexics' response time for correct answers



Graph 9 Control group's response times for correct answers



3.7 Discussion

Analyzing the results, dyslexic adults' performances seem to corroborate the hypothesis that in adulthood difficulties persist in understanding negative sentences introduced by the negative particle non. As shown in the previous section, the percentages of correct answers with negative sentences are, in fact, lower than the average, whereas with affirmative sentences dyslexics show equal or higher rates of correct answers if compared to the control group. This only partially confirms the hypothesis formulated by Vender (2011) with a study on dyslexic children in which she found that children, when asked to interpret negation, commit more errors in all conditions. As McLoughling (1997) suggests, dyslexics in higher education may have compensated or developed strategies to bypass the difficulties they experienced in early life, so adults with a diagnosis of developmental dyslexia may have found a method to compensate their problems in comprehending at least positive sentences and, in part, negative sentences.

Vender also found that true sentences were more difficult to comprehend than negative ones, as predicted by her Model of Sentence-Picture Verification, but as it is possible to note in the previous section from the table showing the percentages of correct answers and the graph describing the trend of reaction times, both types of negative sentences seem to be more problematic to comprehend for dyslexic adults. In particular, she argued that true negatives may be more difficult to process than the false sentences because the picture is not congruent with the situation described in the sentence. In this case the comprehender must create a mental representation of the sentence against the picture. As it is predictable, this process is very expensive in terms of resources and, according to her results, true negative sentences are more difficult than false negatives.

In this study results seem to contest Vender's, displaying that dyslexics seem to have difficulties in coping with both types of negative sentences as we can observe from

the average reaction times for uncorrect answers that are above 4s, higher than the average. Analysing the rate of correct answers, it is possible to note that with false negatives they show lower rates of correct answers with a percentage of 90% in contrast with the 92% of true negatives. A possible explanation for these results has been provided by Kaup et al. (2006) who studied negative sentences with contradictory predicates. Taking as an example the sentence The door is not open comprehenders have available a representation of a closed door, just as they would with the corresponding affirmative sentence with the same truth conditions the door was closed. Kaup et al. argue that the difference between negative and affirmative sentences lies primarily in the fact that affirmative sentences are easier to process than negatives and then in their representational process because in the affirmative version, the subject represents only the closed door, but in the negative version comprehenders represent both the open and closed door, whereby he/she first focuses the attention on the open door and then on the closed one. Given that the processing of negative sentences is assumed to involve mentally simulating the negated state of affairs as postulated by Kaup et al. (2007), it is possible to hypothesize that the results of this study with negative clauses may be assimilated to this assumption. As explained in section 3.4, false negative and true negative sentences are not congruent with the picture shown to the subject because they negate what one of the carachters in the picture is doing. In this sense if we take the false negative sentence “Marge non sta lavando i panni” [Marge is not washing clothes] and a picture depicting Marge who is actually washing clothes as an example, given that the subject heard a negative sentence, according to the Two-Step simulation Hypothesis formulated by Kaup, Zwaan & Lüdtke (2007), the comprehender may mentally represent the situation in which Marge is washing clothes, the situation in which Marge is not washing clothes as in the sentence heard and then, at last, the subject sees the picture in which actually Marge is washing clothes which is contradictory to what the comprehender heard, in other

words it represents a deviation from expectancies. Arguably, the process may be the same for true negative sentences. In this sense, on the basis of the results collected in the present study, it is possible to hypothesize that this type of process for dyslexics is very demanding in terms of Working Memory and explains the slower reaction times and the lower rate of correct answers in both types of negative sentences. According to the results, the following ranking can be proposed:

False affirmatives > true affirmatives > true negatives > false negatives

where false negatives are the most difficult to process, with the highest error rates. Shifting the point of view from the rate of correct answers to the average reaction times for uuncorrect answers, these data seem to confirm Vender's results showing that the slower reaction time has been recorded with true negatives.

Analyzing the data collected in its complex, it is possible to observe that at least for what concerns the affirmative type of sentences the "catch-up" between dyslexics and the normals in the reading and comprehension abilities as postulated by Satz and Van Nostrand (1973) may have occurred, dissolving every possible difference in terms of accuracy of the answers but always maintaining slower reaction times for dyslexics.

For what concerns the control group, the only data that may be quite surprising is the lower rate of correct answers (96%) with true affirmative sentences, which are supposed to be the less difficult to process because they are congruent with the picture shown during the test. Arguably, future studies may help to provide relevant information with respect to this issue.

Conclusions

The data collected in this study seem to contest the results proposed by Vender (2011), highliting that dyslexic adults show difficulties in coping with negative sentences, in particular with false negative sentences more than true negative sentences. This, indirectly, confirms also the Working Memory deficit hypothesis.
For what concerns affirmative sentences, dyslexics' performances seem to be comparable in terms of accuracy of answers, whereas reaction times remain slower than the average.
Since this is only a preliminary study, these hypotheses require further analysis to be confirmed.

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