Neurolinguistic late-side effects of childhood cancer treatment

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Abstract

The survival rate for children with brain cancer and tumours (CNS) has been going up in the last years. At the same time, different communicative, cognitive and psychological late-effects have been observed. These sequelae have a direct impact on the survivors's academic performance, emotional state, social interaction, and the children's quality of life in general.

The objective of this paper is to focus on the communicative difficulties most commonly observed in children survivors of brain tumours treated at Virgen del Rocío Hospital in Seville (Spain):

- Morphological
- Lexical
- Structural or syntactic
- Pragmatic
- Non-verbal

Identifying the main communicative deficits will help us to develop appropriate recovery strategies and training programmes for school and social integration of children survivors.

1. Introduction: a historical overview of the brain-language connection

Different areas have proved to be affected by cancer treatment (Ahles & Saykin 2001, Schultz *et al.* 2007,) and communication is one of them. Many children survivors of cancer have difficulties with language comprehension or perception, with language production, with linguistic memory and with language acquisition. In some cases there is even language loss. The explanation for these side effects after cancer treatment is in the connection between brain and language.

The literature on the relation between brain and language is very old and extensive. The first examples date back to ancient Egypt with *The Edwin Smith Papyrus* (3000-2500 BC), a 4.68 metre-long scroll written right to left in hieratic. It is a collection of 48 medical cases, some of them head and brain injuries. In the description of cases, the author suggests that brain functions are localized in specific parts of the brain.

Studies on the functions of the brain were also found in ancient Greece texts. According to Hippocrates (460-375 BC), known as the father of western medicine, the four nature elements -water, earth, fire and air- are represented by four fluids in the human body: phlegm, black bile, yellow bile and blood. The Greek physician also thought that the brain not only controlled the balance of these body fluids but it was also the organ of the intellect (*mnemonikon*). One of his many contributions was the extensive documentation on his findings, where he (or his students) took notes of his clinical observations and methods. In one of those cases, he describes a man with a loss of memory for letters and he related this language disorder with the paralysis of one side

of the body (hemiparesis). In this particular case the paralysis was on the side of the body opposite to that of the brain lesion.

Plato (423-347 BC), the Greek philosopher, was the first to localize different abilities in different brain areas. In contrast to Plato, the also Greek philosopher Aristotle (384-322 BC) thought that the centre of nervous functions was not the brain but the heart (cardiocentric hypothesis). The brain is then an organ with a minor role as the "cooler" of the body. He added a fifth element to the four previous nature elements. The new element, aether, is a divine substance that surrounds earth, air, water and fire. Among many other areas, Aristotle studied memory, which was described as a mental picture. He thought that memories were imprinted in a semi-fluid organ, which could take different shapes in order to represent every possible mental image.

The Roman Empire was still under the influence of Aristotle´s cardiocentric view. It was not until Galen (129-216 AD) that there was a shift from cardiocentrism to cerebrocentrism. Galen, as a surgeon in the Roman Empire, could examine many gladiators' head wounds and he noticed that there were important differences between the cerebrum and the cerebellum tissues. The cerebrum tissue was softer than that of the cerebellum and, because of this, he thought that the cerebrum was the area for thoughts and feeling whereas the cerebellum was in control of muscles. Apparently, there seems to be no connection between one thing and the other but to some extent his conclusions have turned out to be true. Human dissections of the brain were not allowed at that time, so Galen had to carry out much of his research by exploring animals. In his observations of animals' brains he found spaces (ventricles) filled with fluids, which was used as an evidence to support the Humor theory.

In the Middle Ages some language problems, like naming errors, are believed to be caused by the amount of fluid in the fourth ventricle, which is also the area where memory was assumed to be localized. Antonio Guainerio in his *Opera medica* (1481) reports the cases of two men with speech disorders, one who suffered from anomia and another one who suffered from motor aphasia. According to Guainerio, these symptoms were caused by excessive phlegm in the fourth ventricle (Benton 2000:139). However, according to some researchers, the connection between language and brain would have been much better explored and understood if more attention had been paid to the surgeons. In this respect, Finger states (2001:372):

> The association between speech and the brain would have been recognized more readily if greater attention had been paid to the surgeons who attempted to remove pieces of broken skull or foreign objects from the brain. A good case study was provided by Francisco Arceo (c. 1493-1573), a Spanish surgeon. He described a workman who was hit on the head by a falling stone. The workman was unable to move or speak until the bone pressing upon the brain was resected several days later.

In the seventeenth century there are many descriptions of language loss, some of them of famous people (William Harvey), but physicians do not seem to have a broad knowledge of how to treat aphasia. As Finger (2001:373) points out "Bleeding, leeching and cupping to draw blood were … accepted treatments for the aphasias, and remained so into the nineteenth century".

A self-description of aphasia, probably the first, is found in the 18th century. Eliasberg (1950) mentions the case of a German theologian, Johann Joachim Spalding (1714-1804), who describes his own experience when trying to write a receipt:

> I sat down and wrote the first two words that were required; but in that moment I was not able either to find the following words in my mind or to carry out the necessary strokes with my pen... ... I tried to speak, to train myself, as it were, and to try and test whether I could say something in a

> connected order; but much as I forced my attention and my thoughts and proceeded with the utmost slowness I became aware very soon of shapeless monstrous words that were absolutely different from those I intended; my immortal soul was at present as little master of the inner tools of language. (Translated by Eliasberg 1950).

There is also a very interesting case of aphasia of a physician, Linné, in 1745. The man forgot nouns (mainly names) and he also presented agraphia. He could not write his own name or the name of his wife or any of his children's. However, he had no problem to read or understand names.

Speech disorders are also taken into account in some of the most remarkable medical volumes of the century. For example, Giovanni Battista Morgagni (1761) deals with this issue in his five-volume *De sedibys et causis morborum per anatomen indagatis* (*Seats and Causes of Diseases Investigated by Anatomy*). He distinguishes three types of speech disorders: 1) loss of voice, 2) uttering sounds devoid of meaning, and 3) speech impairments associated with abnormal appearances of the tongue (Finger 2001:373). Johann Augustin Phillip Gesner was also the author of a five-volume publication and he stated that language disorders were related to specific problems in verbal memory, such as impossibility to associate images with the linguistic expressions or, in other words, inability to do the right associations between thought with words.

It is not until the 19th century that some important advances on the relation between language and brain are found. There are many publications on the locatization of language in the brain (Gall & Spurzheim 1810; Bouillaud 1825a & 1825b; Broca 1863, 1965, 1969; Wernicke 1874), on the distinction between production and comprehension and on the nature and types of aphasia (Osborne 1933, Lordat 1843).

The nineteenth century starts with Franz Joseph Gall's theory about speech, which was published in 1819 in his *Anatomie et Physiologie du Système Nerveux*. He stated that the faculty of spoken language was localised in the area behind the eyes:

> The competence to skillfully learn words and names by heart and to save them in memory is seated in the posterior part of the eye socket. In people in whom this organ is very developed, the eyes are situated very much forward so that they seem to posses large eyes [Gall, Selpert, & Van Doornik, 1805, p. 91]

Besides, he also maintained that the cerebral cortex, where speech was localized, was divided into functional units. However he still thought both hemispheres could work independently and performing the same functions.

Afterwards, Bouillaud continues with the study on the lozalization of speech functions. He argued that there is a brain area that is in charge of the production and coordination of movements necessary for communication. Bouillaud states (1825b, Translated in Head 1926:15): "From the observations I have collected, and from the large number I have read in the literature, I believe I am justified in advancing the view that the principle law-giver of speech is to be found in the anterior lobes of the brain".

In opposition to Gall, Paul Broca, a French physician and anthropologist, did not agree with the existing idea that language capabilities could be associated with the size of the frontal lobes of both hemispheres. Instead, he argued that language capabilities were related to particular ridges or convolutions of the hemispheres. He studied a patient, M. Leborgne, who had problems with speech production but not with comprehension. When the patient came to autopsy, it was observed that he had a damaged area in the left hemisphere (Broca's area, localized in Brodmann's map in areas 44 and 45; see FIGURE 1 below). After the analysis of other cases, he stated that the left hemisphere was the location of language production. Additionally, he also

associated left hemisphere dominance with right-handers and right hemisphere dominance with left-handers. Nowadays we know this is not completely true, since the left hemisphere is dominant in 95% of right-handers but also in 60% of left-handers.

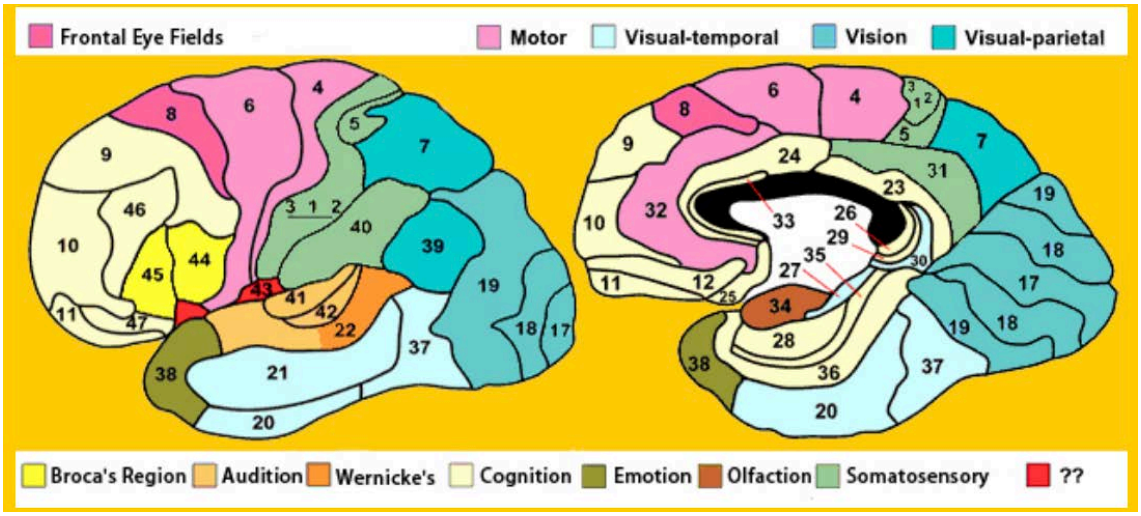

FIGURE 1. Brodmann's map (from spot.colorado.edu)

Carl Wernicke's research (1874) shed some light on the problem. The German neurologist also studied a patient with language disorders, but in this case he had no problems with speech production, like Broca's, but with comphrehension or reception. When the patient came to autopsy, a damaged area was observed in the left hemisphere of the brain, temporal lobe (Wernicke's area, localized in Brodmann's map in area 22). The study of this case and some other similar cases led Wernicke to the conclusion that this was the location to store auditory word images, necessary both for speech production and comprehension. After some time, Wernicke also asserted that there was a connection between the two areas, Broca's and Wernicke's. Consequently, speech production would be affected not only by Wernicke's area but also by any damage in the connection between the two areas. Wernicke's approach is considered to be the first neurolinguistic theory.

Lichthein goes a little further and proposes a diagram (Figure 2) to explain the language processing in the brain. He states that there are three centres or areas –concept center (B), Broca's area (M) and Wernicke's area (A)- and there are also connections between them.

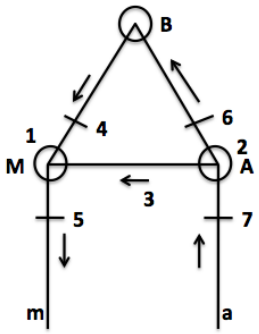

FIGURE 2. Adaptation of Lichtein's diagram

The connection from a to A represents the auditory input to Wernicke's area the one from M to m represents the motor output from Broca's area. The line from A to M is the connection between Wernicke's and Broca's areas. The A to B tract is the connection

necessary to understand spoken input and the one from B to M is the connection for meaningful verbal output. Lichthein was the first to describe the effects of the lack of connection between the concept center and Broca's area (transcortical motor aphasia) and the lack of connection between Wernicke's area and the concept centre (transcortical sensory aphasia). The numbers indicate the seven possible types of aphasia.

In the 20th century the focus of research centres on language functions and the connection they have with different brain areas. There are different views to explain these connections:

a) Localism's followers support Broca's and Gall's beliefs that language functions are associated to some specific areas in the brain but they consider some modifications are necessary. According to localizationists, the reason for a language problem could be any damage in the corresponding area of the brain.
b) Associationism or connectionism, instead, does not hold the idea that specific parts of the brain are in charge of specific language functions. On the contrary, connectionism's supporters argue that language functions can be performed only by means of brain areas that are connected (Ahlsen 2006, Stemmer and Whitaker, 1998). Thus, the reason for aphasia is a wrong or broken connection between the areas.
c) Another approach is the so-called 'Dynamic localization of function' (Luria 1973, Obler & Gjerlow, 1999, Vygotsky 1965). In this theory, there is not a single area associated to a language function. Instead they state that there is a dynamic process in the brain where different areas are used following different organizations in a dynamic way. When there is brain damage the areas involved adopt different organizations.
d) In holism, they prefer to speak of the whole brain as responsible for the language functions. The brain works as a whole (Marie 1906, Head 1926, Goldstein 1926).
e) Evolution-based or hierarchical theories hold that the brain is structured in layers, which are different in children and adults and that is why they process language in a different way. They also focus on how the relation between language and brain has evolved over the years and in different species (Brown 1982).
f) According to Unitarianism, language brain and soul are one. Consequently, different areas in the brain cannot be identified as responsible for specific funstions, for it is not only the brain that performs language functions.
g) Equi-potentiality theory's followers (Lashley, Lenneberg) maintain that the right and left hemispheres work equally, so if there is brain danage in the Leith hemisphere, the right hemisphere will perform tha language functions.
h) In Quantum Theory, or computer analogy theory, language exists in all human beings' brains as long as they are alive.

Last, the so-called Linguistic Approach tries to show how a deep analysis of language pathologies can lead to a better understanding of language processing and structures. Thus, Jakobson (1956:239) states that "any description and classification of aphasic syndromes must begin with the question of what aspects of language are impaired." A few years later, Whitaker was the author of the first doctoral dissertation on language and the brain, published some years later as *On the Representation of Language in the Human Brain* (Whitaker, 1971). At the end of the century, Chomsky believed that language is innate, so humans are born with a capacity for language, although it is also influenced by experience. According to him, children learn labels for

concepts that already exist in their minds and humans are able to do that because we are born with a set of tools (LAD, Language Acquisition Device) that allows us to acquire and produce language (Chomsky, 1965:25). Chomsky added that the set of limited rules for grammar that all humans have are universal for all natural human languages (Universal Grammar).

2. Language dysfunctions

As illustrated in the literature, the brain is the location for speech and language functions (see FIGURE 3), but also for cognition, memory and pragmatic and semantic associations. Although there is much to be discussed about connections in the brain, it seems to be widely accepted that most of the language and learning disorders of children survivors of cancer are a consequence of their brain damage, either because of the tumour, or because of its treatment with surgery, chemotherapy and/or radiotherapy.

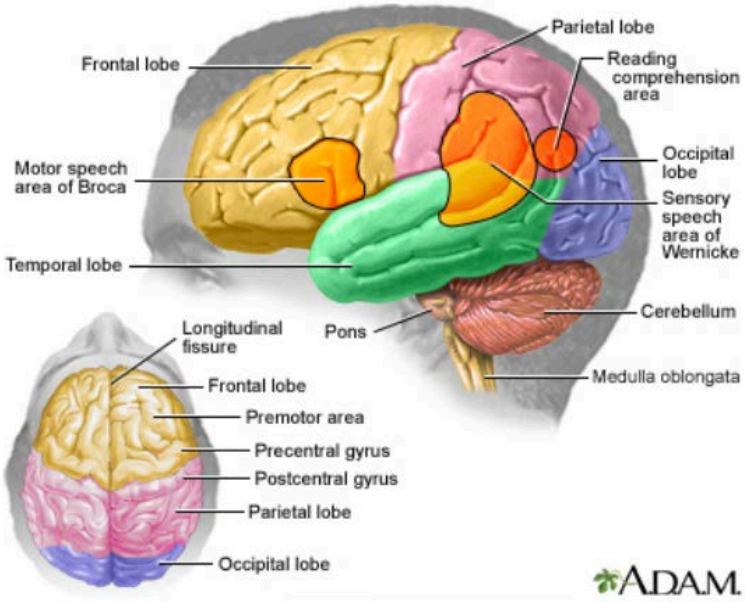

FIGURE 3: Brain Areas (from www.medlineplus.gov)

Some patients have problems with the sentence structure (using a wrong combination of words), others are fluent in production but they cannot decode the messages they receive, other patients have difficulties to remember words, and in some cases patients are unable to repeat a sequence of words, etc. A detailed classification of language and cognitive disorders in cancer survivors would be necessary in order to look for the relationship between type of disorder and each of the following variables: type of surgery, type and dose of chemo drugs used, type and dose of radiation, area of the body being treated, child's age, etc.

But the interest should not only focus on the nature of the impairment but also on the possibility of recovery and rehabilitation. Can cancer survivors suffering from any language or cognitive disorder recover so that their brain performs the same functions as before? Does the recovery depend on the nature and typology of the language disorder?

As mentioned earlier, language is one of the areas affected by cancer treatment. But language cannot be understood as an isolated tool humans use to communicate. It is also the means to learn, to associate ideas, to memorise, to organise thoughts, to socialise with others, to express emotion and feelings, etc. All this means that whenever

a child has a language disorder, all the other areas are also affected and, consequently, it has an impact on the child's quality of life.

The "wait and see" approach does not seem to be the most appropriate one, for children are in the process of intellectual development and a delay in the detection of language difficulties may cause many other problems. Thus, the first step to work with cancer survivors' rehabilitation should be to identify the typology of linguistic difficulties or language impairments.

There is a large number of useful assessment tools available for this purpose: ALB (Assessing Linguistic Behaviors Communicative Intentions Scale), CELF (Clinical Evaluation of Language Fundamentals), PPVT-4 (Peabody Picture Vocabulary Test), TNL (Test of Narrative Language), TOPL (Test of Pragmatic Language), OWLS (Oral and Written Language Scales), WISC-IV (Wechsler Intelligence Scale for Children), GSRT (Gray Silent Reading Test), KTEA-II (Kaufman Test of Educational Achievement). However, none of the above-mentioned tests is a complete method of assessment by itself, since they measure different functions, capabilities or skills.

In the case of children survivors of cancer, both the psychologist and the linguist should work hand in hand in order to carry out a complete evaluation of the patient's cognitive and linguistic functions and abilities. Besides, a first brief examination of the patient is recommended in order to decide on the tests to be used in the evaluation, depending on whether the child has difficulties with production or with comprehension or with both of them, and also depending on the degree or severity of the difficulties (poor articulation or dysarthria, loss of speech or anarthria, inability to understand or receptive aphasia, etc.).

3. Methodology

With the objective of providing an inventory of the most typical language problems presented after cancer treatment, a study was carried out with 12 children survivors of cancer (7 boys and 5 girls) in collaboration with the *Spanish Association for long-term side effects of cancer treatment* (*Asociación Española para los efectos del tratamiento del cáncer –AEetc*). Our first intention was to have the same number of girls and boys but it was not possible due to different health complications during the process of our study.

Regarding the subjects' age, 4 of the children were 6-8 year olds, 4 were 12-13 and 4 were 14 years old. We also studied a control group of 50 children (a balanced representation of the three age groups), not to make a comparison between the groups, but in order to know the average behaviour of children regarding the use of language.

The tests carried out for cognitive and language evaluation after cancer treatment were the following:

1) WISC-IV (Wechsler Intelligence Scale for Children), which provides the child's intelligence quotient (IQ) and the scores in the areas of verbal comprehension, perceptual reasoning, working memory and processing speed.

2) A semi-guided 30-minute-long conversation on everyday matters where the child is asked to describe his/her daily routines, relationship with other children at school, the subjects he/she likes most, relationship with other family members, hobbies, and the things or activities he/she doesn't like. The main objective of this test is to analyse: the

subject's language production (articulation, vocabulary, word relations, sentence structure, media length of utterance, rate of lexical diversity and pragmatic fluency) and his/her comprehension of instructions with different levels of complexity.

3) A writing test on a selected topic, its main objective being to analyse the child's production (use of vocabulary, number of content and function words, sentence structure, connection of sentences, use of language in context, etc.)

4) A reading comprehension test. The purpose of this test is to evaluate the child's ability to understand language. The test is divided into different sections to assess the child's understanding of specific vocabulary and ideas expressed in the text, but also his/her ability to understand the structure of the information provided or the author's point of view.

5) A listening comprehension test, to evaluate the child's auditory capabilities (word recognition, phonetic discrimination) as well as the aspects described in the reading comprehension test.

6) Watching Cartoon Test. The child is asked to watch a short animated cartoon and then he is asked to narrate what he has seen. With this test we analyse language memory, syntactic structures used, synchrony of verbal and nonverbal signals, eye contact, nonverbal behaviour, etc.

After carrying out all these tests, parents are also asked to cooperate by taking notes of the most common language mistakes their children make, so that we can incorporate specific examples into our study, and maybe shed some light on some particular noticed problems.

The final objective of all these tests is not only to detect and diagnose language difficulties, including the severity of the difficulty and its nature, but also to evaluate language strengths. The evaluation will also provide us with a battery of expressive and receptive language difficulties, which will be necessary in order to do a list of recommendations for the child rehabilitation plan.

4. Results and discussion

The data resulting from our study show that children survivors of cancer present a variety of language disorders associated both to production and reception.

The data reveal that language problems are present at different levels of analysis: morphological, lexical-semantic, structural or syntactic, pragmatic and non-verbal. This sequence will be followed for expository convenience.

4.1. Morphological dysfunctions

One of the first disorders we have observed is that 41.7% of the assessed children exchange consonants of words (commonly known as spoonerism), either in presence or in absence. The exchange can take place within the word itself (**marandina* instead of *mandarina*) or it may involve the consonants in subsequent or close words, generally in the first syllable (**porro folar* instead of *forro polar*):

(1) Hace mucho frío. Me voy a poner el porro folar.
[It is very cold. I am wearing my fleece]

This exchange, as noticed, takes place at the sytagmatic level (in presence), since the letters exchanged are explicitly present in the words in the sentence. However, it has been observed that this consonants exchange can also occur in absence or at the paradigmatic level (*pote* instead of *bote*, *potas* instead of *botas*), consonants which are not clearly present in the sentence chain:

(2) Me ayudas a abrir el pote?
[Can you help me to open the bottle?]

The exchange in presence has turned out to be more frequent than the exchange in absence (70% of the cases). Regarding exchange in absence, it is worthwhile mentioning that the consonants involved in the exchange are close in articulation, mainly bilabials (p, b, m).

A smaller number of children (25%) insert an intrusive consonant in a word (known as epenthesis) as an influence from the preceding or subsequent word (*blota de plástico* for *bota de plástico*), the most typical inserted consonant being "l".

Sometimes the syllables in a word are reorganised ("hubo" instead of "buho" [owl]). In some cases the new syllable arrangement tries to shape and sound like the preceding word: "que te has colao, calabao" instead of "que te has colao, bacalao").

4.2. Lexical and semantic dysfunctions

The lexical level is one of the most severely affected. Many children (83.3%) have difficulty to find the correct words, mainly nouns (anomic aphasia) and verbs. The problem affects only the verbal behaviour and the nonverbal production is generally intact. So many children make use of hand gestures that correspond to the object for which they cannot find the name. Some cases of anomic aphasia are tough to diagnose because patients tend to replace the word they cannot remember with other terms semantically related. Thus, children tend to use general words like hyperonyms ("árbol" [tree], "animal" [animal], "fruta" [fruit]) when they cannot remember the hyponym, which is a type of the general word specified by the hyperonym ("encina" [holm oak], "canguro" [kangaroo], "níspero" [loquat]).

Sometimes, the substitution implies the use of a holonym preceded by a determiner plus "parte de" [part of], when the child cannot remember the meronym. In most of these examples, the structure "determiner + part of + holonym" is followed by a modifying clause to specify meaning:

(3) Mmmm … una parte del castillo que es alta y sirve para vigilar.
[Mmmm … a part of the castle which is high and is used to watch]

Co-hyponyms are also a solution for the word the child cannot recall: "whisky" [whisky] instead of "champán" [champagne], "canguro" [kangaroo] for "gorila" [gorilla], "manzana" [apple] instead of "pera" [pear], or even "farola" [streetlight] for "lámpara" [lamp] etc.

Another strategy used by children to compensate for their lack of lexical fluency is the creation of new words, neologisms. So, it is not rare to find words such as: "tapiteo" instead of "tapeo", "miscación" for "crispación", or "suplementoria" for "supletoria". As noticed, these words keep some type of morphological relationship. In "tapiteo" the root of the word is kept (tap-a, tap-ear, tap-eo) but the derivative suffix to

form the noun is new. On the contrary, in “miscación”, the derivative suffix of the original word is maintained but the root is invented. The last example “suplementoria” is an interesting case of blending of the words “suplementaria” and “supletoria”, in fact, the word the child was trying to use was “supletoria”:

(4) Mamá, vamos a tener que poner una mesa suplementoria para poner los platos de postre, el pan y el agua porque no cabe todo en la mesa.
[Mom, we will need an extra table to put the dessert plates, the bread and the water because it does not fit on the table]

In some occasions there is no apparent relation between the word used by the child and the intended word but they are semantically connected because both terms are associated to a common semantic field. The example below is a description by a child who is trying to tell her mom what she has seen in the street a few minutes before, a bacherolette party:

(5) Oí un montón de ruido, música, risas y chillidos. Estaban locas, mamá. Estaban todas bebiendo … mmm whisky en una -, una -, una swarovsky rosa.
I heard a lot of noise, music, laughing and shouting. They were crazy, mom. They were all drinking … mmm whisky in a pink -, a pink -, a pink swarovsky]

In this example, the first problem the girl finds in her description is the word for the drink. She says “whisky” but afterwards in the conversation, it could be clearly seen that the girl meant the co-hyponym champagne. Then she uses the word “swarovsky” to mean “limousine”. There seems to be no apparent connection between the two terms “swarovsky” and “limousine” but in fact there is because the two of them are associated in the child’s mind to “glamour”.

It is also worthwhile mentioning that there are significant differences between the experimental group and the control group regarding the rate of lexical diversity (RLD). The RLD measures the number of different words used in discourse. Generally the RLD in written discourse is higher than in spoken discourse (Halliday 1985) because subjects have more time to think how to express a message and they select vocabulary more carefully in order to avoid repetitions of the words already used. The data show that the experimental group presents not only a lower RLD than the control group both in speaking and writing, but also smaller difference between spoken and written discourse. This is highly associated to the use of repetition by children in the experimental group with language difficulties.

4.3. Structural or syntactic dysfunctions

The difficulty to understand complex syntactic structures is by far the most common dysfunction which has been found in this study, affecting 91.7% of the children in the experimental group.

In general, experimental children have no problem decoding simple sentences and compound sentences linked by coordinated conjunctions. In contrast, subordination tends to be more difficult to understand, the main problem being that children have difficulty to identify the relationship between the main clause and the subordinated clause: temporal, causal, conditional, consequence, purpose, etc. This difficulty

generates many problems, for example, in exams (as described by children and their teachers). Children are sometimes unable to answer an exam question because they do not understand what they have to do or what they are being asked, even though they have studied for the exam and they know the answer. This obviously affects the child's self-esteem and academic performance.

Apart from the problem associated to the type of sentences, already mentioned, children have also proved to have difficulty to decode the meaning of sentences that do not conform to the canonical word order. Any alteration or rearrangement of the elements in the sentence structure implies an additional effort on the part of the child to understand the message. For example a sentence with the structure OVS (object-verb-subject) is harder to be processed and understood than an SVO structure, which follows the canonical sentence order.

Structural ambiguity is also a source of complexity. In this type of constructions the same string of words may have more than one parse, which means the sentence has, at least, two possible interpretations. When children are exposed to structural ambiguity, they generally have no problem with one of the interpretations but it is difficult for them (91,7%) to abandon that view and see the other possible reading(s):

(6) Los padres del niño y la niña vinieron a mi oficina.
[The parents of the boy and the girl came to my office]

When children in the experimental group were asked "who came to my office?" they answered "the parents of the boy and the girl" and when they were asked "how many people came to my office?", their answer was "two, the father and the mother". In this interpretation "of the boy and the girl" is postmodifying the head of the Noun Phrase "parents":

[The parents [of the boy and the girl]]

It was difficult for them to see another reading, even though they were told there were other possible interpretations. An explanation was necessary for them to understand that the answer for the second question could be three, the parents of the boy, on the one hand, and the girl, on the other hand. In this second interpretation, there is a coordination of two Noun Phrases, "the parents" (postmodified by "of the boy") and "the girl":

[The parents [of the boy]] and [the girl]

Another interpretation could be that 4 people came to my office, namely the father and the mother of the boy, and the father and the mother of the girl[1].

[The parents [of the boy]] and [~~the parents~~ [~~of~~ the girl]]

Children in the experimental group also had problems to see the two readings of the following example:

(7) El pollo está listo para comer.

[1] There are even some additional interpretations depending on the referents of the noun "parents" (Both the father and the mother, or just the mother, or just the father of the boy and /or the girl).

[The chicken is ready to eat]

What they understood in example (7) was that “the chicken” was the object of the transitive verb “eat”. It was not until they were shown the picture in (8) that they understood the chicken could also be the subject of the verb “eat”, which in this case is used as a pseudo-intransitive verb, since the object is not expressed:

(8) The chicken is ready to eat

Another aspect to be taken into account is the mean length of utterance (MLU), which is closely related to the utterance complexity and structure (taking an utterance as a unit that contains a complete thought). The MLU is calculated counting the number of morphemes in 100 utterances and dividing this number of resulting morphemes by 100 (the number of utterances). The experimental group in this study had a much lower MLU than the control group, which implies a lower level of language fluency.

4.4. Pragmatic dysfunctions

When we interact with other people, much of the information we communicate is implied rather that uttered. This means that the hearer must decode not only what is explicitly mentioned in the message but also what is implicit. In other words, the hearer has to “read between the lines”. To make the right interpretation of the message, the hearer must understand the words expressed in the utterance (locution), but also the speaker’s intentions (illocution), and the context where the message is uttered. The data reveal that the children in our study tend to use a type o literal decoding and, consequently they find it very difficult to understand implied, indirect or connotative meaning.

Being fluent in a language means not only to know the vocabulary and the rules of the grammar to combine those words into grammatical or correct sentences, but also to know how to use the language in context. The fact that a sentence is grammatical does not mean it is appropriate in every context, and many of the children (50%) in the experimental group have made use of well-formed sentences or expressions in the wrong context or situation.

4.5. Nonverbal dysfunctions

Children survivors of cancer show a high use of hand gestures, as it has been mentioned at the beginning of this section.

Three main types of gestures have been found to be more frequently used: emblems, illustrators and adaptors, which are very different in nature and also differ in function.

Emblems are body gestures which can be translated into words and which are consciously and purposely performed. They can co-occur in synchrony with words with the same meaning or they can be used in isolation without the support of words. Children in the experimental group try to compensate their lack of fluency with emblems, but also with illustrators.

Illustrators are signals that complement verbal messages, generally hand gestures and head and body movements. Apart from being used to complete, complement or modify a verbal message, they are said to increase the ability to remember, and perhaps this is one of the reasons why they are so frequently used by subjects with language problems (more research is necessary to explore this hypothesis).

Most children with language problems are very nervous when they have to interact with other people, which may be the reason why they use so many adaptors. They are gestures, generally performed unconsciously, that satisfy personal needs and release the body tension but they provide no meaning related to the verbal message. Some children touch their ear lobe or their nose, others cover their mouth or rub their forehead, or even cough to feel more comfortable.

Another finding regarding nonverbal communication has to do with eye-contact. Children with more severe language problems avoid eye-contact and this is, together with the other language problems mentioned in this paper, a barrier for communication and, in consequence, for socializing. Not keeping visual contact will be an obstacle to regulate the flow of communication, will not allow the speaker to express emotions, will make it very difficult to monitor feedback and will probably impede interpersonal relationships.

TABLE 1 below shows a general overview of those variables analysed both in the experimental and the control groups:

TABLE 1. Language Difficulties after Cancer Treatment

		Experimental Group	Control Group
	Difficulty to find the words	83.3% (10/12)	4%
	Difficulty with articulation	25% (3/12)	0%
	Exchange of consonants	41.7% (5/12)	0%
	Insertion of consonants	25% (3/12)	0%
	Difficulty understanding instructions with complex sentences	91.7%% (11/12)	10%
	Difficulty to understand lexical ambiguity	66,7% (8/12)	8%
	Difficulty to understand structural ambiguity	91.7 (11/12)	16%
	Wrong use of language in context	50% (6/12)	2%

Conclusions

Our findings reveal that the most important language problems found in children survivors of cancer involve different linguistic areas: morphology, syntax, semantics, phonology, pragmatics, etc., both at the levels of production (ability to express or encode a message) and reception (ability to understand what is said). These language dysfunctions are:

- Consonants exchange at the syntagmatic level (in presence) and at the paradigmatic level (in absence).
- Insertion of intrusive consonant, mainly “l”.

- Wrong reorganisation of syllables in the word.
- Difficulty to remember words, mainly nouns and verbs.
- Preference for hyperonyms to avoid specific words (hyponyms) when the subject cannot remember them.
- Preference for holonyms in the structure "determiner + part of + holonym" to replace the meronyms.
- Use of co-hyponyms and neologisms to compensate for their lack of lexical fluency.
- Substitution of the forgotten word by another term which is semantically related.
- Low Rate of Lexical Diversity (RLD).
- Difficulty to understand complex syntactic structures: subordination, ambiguity, sentences which do not conform to the canonical patterns.
- Low Mean Length of Utterance (MLU).
- Difficulty to understand the illocutionary force of messages.
- Wrong use of words in context.
- Excessive use of emblems, illustrators and adaptors.
- Very little eye-contact.

Since language is a very complex system that develops basically in the first years of life[2], children diagnosed and treated earlier in age presented more severe damages in language comprehension and production.

It is very important that language problems are detected as soon as possible because they may have an impact on the child psycho-social and emotional development and they may also lead to other mental and learning problems, academic failure, and even school dropout.

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[2] It is worthwhile mentioning that language acquisition is an ongoing process starting in the first years of age but extending into childhood and adolescence.

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