The Role of Memory Systems in Specific Language Impairment- Procedural Memory System Dysfunctions

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Abstract
This study aims at discussing the role that Memory Systems play on Specific Language Impairment (SLI) and the problems caused by the dysfunctions at the Procedural Memory System. After a brief examination of what Specific Language Impairment is, its causes, what the linguistic profile of children with SLI is, and finally, the Declarative and Procedural Memory Systems (DP Memory Model (Ullman, 2008)), I attempt to make a connection between Specific Language Impairment and the Declarative-Procedural Memory Systems; the ultimate goal is to put emphasis on the language problems caused by the dysfunctions at the Procedural Memory System. The main findings of this study indicate that SLI is a developmental language disorder that delays the mastery of language skills and it also refers to a disorder of language production; the most important is that SLI can be best interpreted through an abnormal growth of the brain structures that support the Procedural Memory System (Ullman & Pierpont, 2005).

Keywords: specific language impairment, procedural memory system, declarative memory system, language profile, linguistic problems, procedural deficit hypothesis

1. Introduction
The ability to acquire linguistic knowledge, including vocabulary, grammar and syntax in one’s native language is a unique human characteristic (Archibald et al., 2011:295). However, this acquisition is not always a natural evolution in the development of all children. This happens because a simple exposure to language is not enough for a small number of children, and their ability to talk does not seem to appear at the expected time, nor does it seem to progress. Sometimes, children fail to speak, or they may organize their language in an abnormal way, which seems disturbed (Alexaki, 2007); it is probable then, that the children described above have a Specific Language Impairment.

2. Specific Language Impairment
Specific Language Impairment (SLI) is usually defined as a developmental disorder of language in the absence of frank neurological damage, hearing deficits, severe environmental deprivation, and mental retardation (Leonard, 1998). SLI belongs to the Special Developmental Disorders and the main characteristic of this disorder in children is the slowest rate of language development compared to other children of the same age although other developmental stages develop naturally and without any problems (Mandourari, 2013).
Therefore, SLI refers to a situation of delayed language development, which exists without the presence of other causes, such as deafness, mental retardation, autism, and children with SLI have normal intelligence, vision, hearing and emotional development (Kolovea, 2010; Samiou, 2011). As regards the first symptoms of SLI, they seem to include a delay in understanding and expressing speech at an early age and some disorders in language development and expression (especially, at the syntactic level) (Markoula, 2003).

It is worth noting that SLI exists since the birth of a child and does not appear as a result of an illness or psychological trauma. Children diagnosed with SLI do not exhibit the same symptoms and they are not a completely homogenous group of children, as difficulties appear in some or all levels of speech organization (phonological level, morphological level, syntactic level, semantic level) at varying degrees (Markoula, 2003).

Last but not least, other terms that have been proposed to describe SLI are the following: Developmental Language Disorder, Language Delay and Developmental Dysphasia (Samiou, 2011).

3. Possible Causes of SLI
Bishop (2006; 2007/08) states that SLI is the result of a combination of factors; each one of these factors seen separately does not seem to cause problems, however, it is their combination that can bring about some dysfunctions.

SLI involves a disruption of production (output disorder), as well as some disturbances in the processes involved in the transformation of deeper linguistic capacity, which remains intact during speech. Moreover, Mandourari (2013) mentions that SLI may arise due to damages that occur at the specific linguistic mechanisms that help in speech processing; there is also damage to the auditory perception of children, affecting, then, the acquisition of speech.

Other possible causes of SLI are the following (Mandourari, 2013): a deficit in the conceptual development, which affects speech processing, the limited speed and capacity of the information processing system, and any learning strategies, which are not normal and do not permit the application of appropriate hypothesis testing procedures.

4. The Language Profile of Children with SLI
Regarding the language profile of children with SLI, some of their characteristics may be the following ones.

First and foremost, they begin to talk at almost the same age as normal children do, but their progress is slower. Besides, children with SLI use simple phrases that may contain syntax errors, one-word expressions, and incorrect verb endings as regards agreement or tense (Samiou, 2011).

What is more, they have a difficulty in understanding the meaning of a new word into a text or apply a new syntactic structure. Next, since their speech development is slower compared to normally developed children of the same age, children with SLI tend to use less words in their everyday talk (Samiou, 2011). They also present some problems in understanding spoken language, but this is not so important.

Apart from the above, children with SLI have difficulty in perceiving the middle and the passive voice, abstract concepts, idioms, metaphors, similes, or other sophisticated expressions. Furthermore, difficulties appear when they perform complex verbal
instructions and they may also have difficulties concerning the understanding of the meaning of a text, as well as the memorization and the recalling of information from the text; all these facts indicate a problem in short-term memory (Karamitsou, 2013). Finally, another characteristic of children with SLI may be the fact that they may display deficits in structural dependency structures, e.g. subject-verb agreement (van der Lely & Stollwerck, 1996), or problems regarding inflectional morphology, or some minor phonological deficits.

5. **Declarative & Procedural Memory Systems (Ullman, 2008)**

According to Ullman (2008:190; 2013:224), the declarative memory system and the procedural memory system refer to the entire neurocognitive systems involved in the learning, representation, retention and use of the relevant knowledge and skills. A dysfunction of one system can enhance learning and functioning in the other, or learning in one system may depress the functionality of the other (Ullman, 2008:191).

More specifically, the linguistic knowledge can be learned, stored and processed by the declarative memory system, thus, in case of a dysfunction in this system, this knowledge can be hampered. In case of a procedural memory system dysfunction, there is a deficit concerning the application of rules in the use of complex forms (Ullman, 2004; 2013). Besides, these two memory systems interact in two ways, either cooperatively or competitively in learning and in processing (Ullman, 2008:192; 2013:225). First, the two systems mutually complement to obtain the same or similar knowledge, including the learning of sequences and rules. Especially, the declarative memory, thanks to the fast learning abilities, helps in the acquisition of knowledge, while the procedural memory helps in the acquirement of similar knowledge, which is, then, quickly processed and automated (Ullman, 2008; 2013). But, let’s see each memory system separately.

5.1. **The Declarative Memory System**

The declarative memory system depends centrally on the medial temporal-lobe structures involved in the encoding, consolidation and retrieval of new memories: the hippocampal region, entorhinal cortex, perirhinal cortex, parahippocampal cortex and ventro-lateral prefrontal cortex (Nicolson & Fawcett, 2007:137).

Regarding the molecular basis of declarative memory, Ullman (2013:224) notes that it is affected by the estrogen levels (high levels improve the declarative memory), the genes from at least two proteins (BDNF and APOE), the biological sex (women tend to be better in terms of declarative memory than men), the hours of sleep (sleep improves memory), and age (declarative memory improves during childhood and adult life and then, it begins to decrease).

Furthermore, the declarative memory system underlies what is traditionally thought of as the mental lexicon (Ullman, 2008:191). It also subserves the learning, representation, and use of knowledge about facts (semantic knowledge) and personally experienced events (episodic knowledge) and it seems to be specialized in learning arbitrary pieces of information and the associations between them. Knowledge is acquired very quickly and can be generalized and used in different contexts (Ullman, 2004; 2008:189; 2013).
5.2. The Procedural Memory System

The procedural memory system underpins the ‘mental grammar’ — the learning of new rule-based procedures that govern the regularities of language (Nicolson & Fawcett, 2007:137) and it underlies the learning of new and the processing of established perceptual-motor and cognitive ‘skills’ and ‘habits’ (Ullman, 2008:189).

This system comprises the basal ganglia, the frontal cortex (in particular, Broca area and premotor regions), the parietal cortex, the superior temporal cortex and the cerebellum (Nicolson & Fawcett, 2007:137). Furthermore, Ullman (2008:189-190; 2013:225) mentions that the procedural memory system consists of a network of interconnected brain structures, which is located in the circuits of the basal ganglia, which comprise the primary motor cortex and the Broca area (BA 44). Factors affecting the procedural memory system are the neurotransmitter dopamine, the genes for certain proteins (protein FOXP2 and DARPP-32) and age (the procedural memory seems to be established early in a person's life, while later on, it seems that learning presents certain deficits).

As for its specialization, the procedural memory system may be specialized for learning rules and sequences and learning in this system requires repeated exposure to stimuli, or practice with the skill or habit. Thus, this system is referred to as an ‘implicit memory’ system (Ullman, 2008:189). Learning in the system requires extended practice, though it seems to result in more rapid and automatic processing of skills and knowledge than does learning in declarative memory (Ullman, 2013:225). Therefore, the procedural learning system shows the important role of procedural memory in language, in motor skills, in acquisition and in implementation skills (Nicolson & Fawcett, 2007).

6. SLI & DP Memory Model of Language – Linguistic Problems caused by Procedural Memory System Dysfunctions

So far, Specific Language Impairment has been explained mainly by two classes of hypotheses posing either a deficit specific to grammar, or a non-linguistic processing impairment (Ullman & Pierpont, 2005:399). However, Ullman & Pierpont (2005:399) went a step further by proposing the Procedural Deficit Hypothesis (PDH); according to this hypothesis, SLI may be largely explained by abnormalities of procedural memory system brain structures and, in particular, of Broca area (BA 44 and 45) within the frontal cortex and the caudate nucleus within the basal ganglia. Besides, a significant proportion of individuals with SLI suffer from abnormalities of this brain network, leading to impairments of the linguistic and non-linguistic functions that depend on it, such as some motor difficulties or motor tasks involving complex sequences of movements, grammar deficits, reading disabilities (Ullman & Pierpont, 2005).

SLI is also strongly associated with grammatical impairments, including impairments of syntax, morphology (morpho-syntax and morpho-phonology) and phonology, which may rely on the same or distinct circuitry within the procedural memory system (Clahsen et al., 1997; van der Lely, 1996; van der Lely & Ullman, 2001). Nevertheless, Ullman and Pierpont (2005) stress the fact that not all people with a Specific Language Impairment present these abnormalities at the procedural memory system, but, still, most of them do so.

On the contrary, the declarative memory system remains intact and it plays an important compensatory role. This view is reinforced by the relatively spared lexical
knowledge in SLI, as evidenced by spared recognition and comprehension in word learning tasks; however, retrieval of lexical knowledge (word finding) is often difficult for people with SLI if structures underlying procedural memory are involved in this function (Ullman, 2004:251; Ullman & Pierpont, 2005; Weckerly et al., 2001).

Apart from these, Ullman (2004:251) mentions that individuals with SLI can often retrieve regular past tense forms and plural forms. What is more, they can sometimes learn explicit rules such as the addition of the suffix -ed in order to make a past-tense form. Moreover, when it comes to compounds with regular or irregular plurals in them (e.g. mice-eater and rats-eater), children with SLI can produce them both; normal children, though, produce compounds with irregular plurals only (e.g. mice-eater vs. rat-eater) (van der Lely & Christian, 2000); so, while normal children retrieve only irregular past-tense forms from memory, children with SLI retrieve both past-tense types (Ullman, 2004:251).

Therefore, the problems that arise because of the procedural memory system dysfunctions can somehow be solved since people with SLI gradually begin to rely on the relatively spared declarative memory system.

7. Diagnosis and Treatment of Individuals with SLI

Regarding the diagnosis and treatment of people with SLI, Karamitsou (2013) notes that professional language and speech therapists design their treatment regimen for individuals with SLI on a personal level taking into consideration a detailed assessment of their spoken and written language.

In addition, children with SLI can be helped through various activities, such as reading fairy tales from the teacher or parent; this activity can help children use language in different communication levels, namely, children can narrate what they heard through the narration of history, they can broaden their vocabulary, improve the organization of their proposals, answer questions, remember the important keywords, ask questions, participate in debates, write or paint specific points of the story that intrigued them (Karamitsou, 2013). Furthermore, Samiou (2011) notes that the therapist is asked to work with each individual at multiple levels, namely, the articulatory, the phonological, the grammatical-syntactic, the metalinguistic, the lexical and the semantic level, depending on the needs of each one’s linguistic development.

Finally, many of the language problems of individuals with SLI are possible to overcome, to a large extent, with intensive intervention and care and by involving children and individuals, in general, in various activities (Samiou, 2011).

8. Conclusions

Taking into consideration all the information provided earlier about Specific Language Impairment and the Declarative – Procedural Memory model of language, the most basic points that arise from this study are the ones that follow.

SLI is a developmental language disorder that delays the mastery of language skills in children and adults who have no mental retardation or other developmental delays. The problem lies in the fact that children with SLI exhibit slower language development, compared with other children of the same age, whereas other developmental stages (e.g. psychomotor) usually develop normally.

Besides, SLI refers to a disorder of language production, as disturbances in the
processes involved in the conversion of deeper linguistic ability into speech are observed; therefore, Specific Language Impairment can affect the understanding, the development and the expression of speech.

At first, SLI was interpreted using two classes of hypotheses, which pose either a deficit specific to grammar, or a non-linguistic processing impairment. Nevertheless, it has been shown that SLI can be best interpreted through an abnormal growth of the brain structures that support the Procedural Memory System (Broca area, frontal cortex, caudate nucleus in the basal ganglia, cerebellum) (Ullman & Pierpont, 2005). Given that disturbance in the procedural memory system, grammatical impairments are observed, as well as some motor deficits (Ullman, 2004; 2008).

Finally, Specific Language Impairment is an interdisciplinary field of study since linguists, speech therapists, psychologists, psycholinguists and geneticists try to understand the basis of this disorder and then, they try different ways so as to offer solutions to the deficits that occur.

References


