European Journal of Foreign Language Teaching
ISSN: 2537 - 1754
ISSN-L: 2537 - 1754
Available on-line at: www.oapub.org/edu

doi: 10.46827/ejfl.v5i2.3369 Volume 5 | Issue 2 | 2020

TOWARDS THE AUTOMATISATION OF A FOREIGN LANGUAGE: SENSORIMOTOR DRILLING, THE STRUCTURATION OF LINGUISTIC INPUT ON THE BASIS OF PROCESSING DEMANDS AND SENSORY CHUNKING

Verónica Mendoza Fernández[i]
University of the Basque Country,
Spain

Abstract:
The current study presents the results of a treatment that sought to improve the 3rd person singular -s of the present simple tense. Sixty-four EFL learners from three different primary schools participated in the experiment. Learners were divided into a control group and two experimental groups. Whereas the control group followed its own school instruction, the two experimental groups followed a treatment that was based on neuroscience and psychology and that integrated innovative pedagogical techniques (©2018, 2019, Verónica Mendoza Fernández): *sensorimotor drilling*, the structuration of linguistic input on the basis of processing demands and *sensory chunking*. Learners carried out four pretest-postest tasks. Here are presented the results of one of the tasks: oral sentence transformation. The findings of the study indicated that statistical significance was reached by the two experimental groups only.

Keywords: foreign language teaching, sensorimotor drilling, sensory chunking, language automatisation, neuroscience, psychology

1. Introduction

The literature on the acquisition of English as a foreign language (EFL) portrays the third-person singular –s of the present simple tense as a linguistic feature that is difficult to acquire and cannot be mastered even at advanced levels of instruction (Ionin & Wexler, 2002; White, 2003; García-Mayo & Villarreal-Olaizola, 2011; Lázaro Ibarrola & García Mayo, 2012; Martínez-Adrián, Gallardo del Puerto & Gutiérrez-Mangado, 2013; Martínez-Adrián & Gutierrez-Mangado, 2015).

The aim of this paper is to present the results of an experiment on the third-person singular –s. The experiment comprised learners from three different primary schools. The

[i] Correspondence: email veronica.mendoza@ehu.eus

participants were divided into a control group and two experimental groups. Whereas the control group followed its own school instruction, the two experimental groups followed a treatment that was designed to facilitate the retention (acquisition, learning) and strengthening of the 3rd person singular -s and, hence, improve its retrieval (accessibility) and use (expression, production). Further, the innovative treatment was implemented in an attempt to not only efficiently teach the 3rd person singular -s but also contribute to language teaching and automatisation. By 'automatisation', the author of the manuscript refers to the process encompassing the retention (acquisition, learning), strengthening (overlearning) and retrieval of (access to) linguistic memories for their automatic organisation and expression −that is, for their effortless, accurate, fast planning and production− in response to particular contexts. To that end, the treatment sought to translate evidence from neuroscience and psychology (including psycholinguistics and developmental psychology) into the foreign language classroom. The treatment was characterised by the integration of innovative pedagogical techniques: *sensorimotor drilling*, the structuration of linguistic input on the basis of processing demands and *sensory chunking*.

Sensorimotor drilling is a form of training in the linguistic reaction to non-linguistic and linguistic stimuli (i.e. visual imagery and spoken sentences) so that learners can translate what they perceive, the world, into linguistic expression and, additionally, can interact with other speakers through linguistic expression. To that aim, this form of practice involves learners' repeated perception of visual imagery that represents particular contexts (i.e. an illustrated tale) and learners' repeated perception and production of linguistic stimuli (here, vocabulary items and chunked sentences) that match the non-linguistic stimuli. In other words, in *sensorimotor drilling*, linguistic stimuli are listened to, read and produced in connection with context-related visual imagery. In terms of automatisation, *sensorimotor drilling* comprises learners' repeated perception and expression of chunked sentences in response to context-related stimuli. With practice, such linguistic expressions could become automatic, overlearned, chunk-based reactions to non-linguistic and linguistic stimuli. *Sensorimotor drilling* seeks to transfer the concept of *sensorimotor integration* to classroom practice. In short, *sensorimotor integration* refers to the process that translates perception into action or language and is dependent on specialised areas of the brain (Fuster, 2003, 2015).

Further, the treatment entails three instructional stages: *Sensorimotor Vocabulary Drilling*, *Sensorimotor Sentence Drilling I* and *Sensorimotor Sentence Drilling II*. The stages were devised to respect the three milestones in language acquisition that can be observed in reviewing relevant literature from the fields of psychology and neuroscience. *Sensorimotor Vocabulary Drilling* hinges on learners' repeated perception and production of vocabulary items while both *Sensorimotor Sentence Drilling I* and *II* rely on learners' repeated perception and expression of chunked sentences and rehearse chunk-based choice, chunk-based order and combination and chunk-based rule implementation. Also, the three instructional stages involve the structuration of linguistic input according to increasing −though cognitively manageable ("easy to deal with")− complexity.

Sensory chunking is a pedagogical technique that involves learners' repeated perception and expression of chunked sentences. Each of the chunks of a sentence is referred to as a *sensory chunk.* A sensory chunk is a block of language that may consist of one or several words. *Sensory chunks* can be listened to, read and drilled. For the current experiment, chunked sentences (that is, *sensory chunks*, including those containing the -s of the present simple, i.e. [He loves]) constituted the linguistic input used to teach the -s. Moreover, *sensory chunks* are cognitively manageable linguistic pieces. According to Miller (1956), the chunking of sequences may contribute to overcome processing overload and favour the retention of such chunks. Also, certain areas of the brain may specialise in the retention (acquisition, learning) and strengthening (overlearning) of *motor chunks* ("the chunks of the brain"). Once overlearned, such chunks are retrieved for the automatic organisation and expression of a skill (i.e. language) in response to particular contexts (i.e. Graybiel, 1998, 2008; Jin & Costa, 2010, 2015; Jin et al., 2014). The author of this manuscript suggests that the treatment, mainly *sensory chunks*, may well contribute not only to the acquisition and strengthening of the -s of the present simple but also to the acquisition and strengthening of *motor chunks*.

2. Literature Review

The author shall now account for the grounding of three instructional stages of the treatment, the structuration of linguistic input on the basis of increasing −though cognitively manageable− complexity, as well as *sensorimotor drilling* and *sensory chunking*. To that end, the author shall present the three milestones that can be identified in the acquisition and expression of a language (that is, the acquisition of vocabulary, early/novel sentences and chunk-based/routinised sentences), on the basis of evidence that stems from psychology (sections 2.1-2.3) and neuroscience (sections 2.4-2.6). The process of sensorimotor integration shall also be discussed in connection with early/novel sentences and chunk-based/routinised sequences, including *motor chunks* (sections 2.5 and 2.6.). Further, the issue of memory shall be tackled in terms of memory processes and additional related aspects, such as the overcoming of processing limitations (section 2.7).

2.1. Psychology: the acquisition and expression of vocabulary

A first meaningful word is spoken around 12-20 months (Bukatko & Daehler, 2004). This has been termed the 'one-word stage'. Young infants are particularly drawn to learn and use words that are functional in their immediate experience and, hence, are dependent on the contexts in which they are uttered (Whitehead, 2007; Schaffer & Kipp, 2014). Nelson (1973) studied 18 infants as they learned their first 50 words, which comprised: family members, daily routines, food, vehicles, toys and pets.

2.2. Psychology: the acquisition and expression of early sentences

At around 24 months of age, children begin to string words into simple "sentences". At first, two-word utterances prevail, but the child soon combines more words in forms that loosely resemble the grammatical structure of their language (Bukatko & Daehler, 2004). This has been termed the 'two-word stage'. Roger Brown (1973) proposed a list of eight combinations (i.e. agent + action) that children express in their two-word utterances. For example, in combinations encompassing agent + action, agents consistently precede actions and inanimate objects are usually not named as agents. Also, the child rarely says, "Wall go" and in order to avoid this kind of verbalisation, the child must know the meaning of words and that walls do not move (Bukatko & Daehler, 2004; see Table 1).

Table 1: Eight relational meanings suggested by Brown (1973, in Hoff, 2014:178)

Combinations	Two-word utterances
agent + action	Daddy sit
action + object	drive car
agent + object	Mommy sock
agent + location	sit chair
entity + location	toy floor
possessor + possession	my teddy
entity + attribute	crayon big
demonstrative + entity	this telephone

A young child produces short, simple utterances due to the existence of restricted, limited cognitive resources. Attention and/or working memory are initially limited and increase over time. Children are forced to "start small". Small incremental changes occur over time and children move from short, simple utterances to increasingly complex syntactic forms (Elman, 1993, 1999; see also Evans, 2009; Owens, 2016).

At age two-and-a-half, children's speech often exceeds two words in length. Adjectives, pronouns, and prepositions are added to the child's repertoire (Valian, 1986; Bukatko & Daehler, 2004). Braine (1976) suggested that early speech contains a unique structure that he called *pivot grammar*. The child recognises that certain words (i.e. more, off) or expressions (i.e. can-I) are quite frequent in the input language. Such items tend to occur consistently in a certain sentence position: for example, 'more' occurs initially while 'off' occurs finally. Braine emphasised these two facts in his explanation of the child's early grammar. In (1) are presented some examples adapted from Braine, 1976:

(1)

Daddy work	big lion	boot off	more music	here this
Daddy sleep	big water	light off	more spoon	here milk
Daddy walk	big light	shoe off	more cookie	here apple
			more open door	

see baby	have it egg	want car	want more
see pretty	have it milk	want cookie	want more… noodles
see train	have it fork	want this	want more hat
		want this… soap	want open door

close… door	look (at) that	can-I fix it	I-can't come in
close… bathroom	look (at) light	can-I-have soap	I-can't get it
open door	look (at) chicken	can-I-have put in	I-can't get open door

Braine claimed that the young infants learn a number of distributional patterns or formulae of limited scope. Each distributional pattern or formula is concerned with a specific, often quite narrow, relational meaning, as shown in examples (2) and (3):

(2) Patterns that draw attention to something (see + X or here/there + X)
(3) Patterns that remark on the specific properties of something (big/little + X)

In this respect, Harris (1990:27) suggested that "*rather than learning adult grammatical rules, children construct their own rules for producing ordered sequences of words*."
Further, Hoff (2014:175) asserted that "*Most children have at least some multiword phrases in their repertoires that have been memorized as unanalyzed wholes; these phrases therefore do not reflect the development of the ability to combine words*" (Peters, 1986). In (4) to (7) are some examples that were uttered by Minh, a girl aged 14 months (Peters, 1983, 1986):

(4) I want
(5) I don't know
(6) Look at that
(7) Open the door

Hoff (2014:185-186) also reported that a child may have a repertoire of rules that allows for very limited productivity, as shown in (8) to (10). She also suggested that "*most children include both unanalyzed chunks and smaller units in their early sentences*." (for further review on the child's learning of chunks, see Wray, 2002; Tomasello, 2003; Bybee, 2010).

(8) There's the X
(9) Me got X
(10) Wanna X

Moreover, psycholinguists found that the order in which some of the bound morphemes are acquired is similar for all children acquiring English (Brown 1973). For example, earliest of all is the acquisition of the *-ing* marker on verbs signalling the present progressive form. The third person singular -s is acquired later (Brown, 1973; see also Fernandez & Cairns, 2011).

Further, middle childhood is a period of syntactic refinement and many important linguistic strides are made at that time. Sentences such as (11) become much less frequent by age 5 to 8:

(11) Him and her went. (Boloh & Champaud, 1993, in Schaffer & Kipp, 2014:359)

2.3. Psychology: Evidence of chunk-based processing

Aaronson and Scarborough (1977) studied linguistic processing by examining the patterns of word-by-word reading times over a sentence when a subject had to retain the linguistic information sufficiently for immediate verbatim retrieval. Twenty-four undergraduates viewed sentences that were displayed one word at a time on a computer. The participants controlled the appearance of each word by pressing a key. Meanwhile, the computer recorded their reading time for the previous word in milliseconds, which allowed the experimenters to measure how long a participant spent looking at each word and the length of the intervals between words. Even though the words were displayed one at a time, the task resembled normal reading when retention is required. The results showed that sentences were broken up into a different number of chunks depending on the subject. In the following sample stimulus sentences (12) to (19), single, double, and triple slashes show, respectively, the natural breaks (prolonged pauses) displayed by 20-30, 40-80, and 90-100% of the control subjects (Aaronson & Scarborough, 1977: 279):

(12) Because of its lasting construction /// as well as its motor's power /// the boat was of high quality.
(13) The newly designed outboard motor /// whose large rotary blades / power the boat /// was of high quality.
(14) In order to make an impression /// Jane wore / an orange and green miniskirt.
(15) As a direct result of the dog's help /// the blind teacher was successful.
(16) The people // who listened to Bill /// thought carefully // about his words.
(17) The obnoxious loud-mouthed barber // who had been attending Dave /// talked continuously // about the increased income tax.

(18) The politicians // supporting Johnson // travelled tirelessly // throughout the country.

(19) Playing in the woods // when gamesmen are hunting moose /// is dangerous.

In the next three sections, the three milestones in the process of the acquisition and/or expression of language (semantic memory, novel sentences and chunk-based, routinised sentences) shall be discussed, together with the issues of sensorimotor integration and *motor chunks,* from the standpoint of neuroscience.

2.4. Neuroscience: Semantic memory

Before addressing semantic memory, a few considerations are made here. The cortex is divided into two main regions: the posterior cortex and the frontal lobe. The posterior cortex is the "sensor" cortex that senses and interprets the world (Fuster, 2015). It encompasses the occipital lobe, the temporal lobe, and the parietal lobe. Roughly speaking, areas in posterior cortex are associated with a general function: occipital lobe with vision, temporal lobe with audition and parietal lobe with body senses (Kolb & Wishaw, 2015). In contrast, the frontal cortex is the "doer" cortex for acting in the world. In other words, whereas the posterior cortex is devoted to perception, the entirety of the frontal cortex (including its prefrontal region, called the prefrontal cortex) is devoted to action of one kind or another, from skeletal movement to speech. Additionally, the basal ganglia (harboured below the cortex) are also devoted to action (Fuster, 1995, 1997, 2015). The areas of posterior cortex are referred to as *sensory areas,* while the frontal cortex and the basal ganglia are referred to as *motor areas* (i.e. Fuster, 1997). The prefrontal cortex and the basal ganglia shall also be discussed in terms of their prominent role in *sensorimotor integration* (see sections 2.5. and 2.6.). Additionally, the basal ganglia shall be addressed in connection with *motor chunks.* Semantic memory is now briefly addressed.

Semantic memory accumulates mainly in networks of multimodal areas that are located in posterior cortex. One of such regions, Wernicke's area, receives input from the visual cortex in the occipital lobe, a region that has been implicated in the visual representation of objects ("mental imagery") and in reading comprehension (word forms). Wernicke's area also receives input from the auditory cortex in the temporal lobe, a region that is essential for speech comprehension (word sounds). Further, the representation of words is said to be enmeshed with the representation of the objects for which they stand and, hence, be part of the same neuronal networks. This may also be the case of foreign words. Lesions to such multimodal regions lead to the inability to name visually presented objects and to identify them by categories, such as inanimate and animate (Fuster, 1995, 1997, 2003; Sherwood, 2012).

2.5. Neuroscience: Expression of novel sentences (linguistic sequences)

As stated, the cortex is divided into two main regions: the posterior cortex and the frontal lobe. Here, we shall focus on the prefrontal cortex, which is a motor area located within the frontal lobe. The overriding function of the prefrontal cortex is the organisation of novel (not routine) sequences (Fuster, 2013, 2015). This area harbours the rules of action and language and is responsible for their implementation (Fuster, 1989, 1995, 1997, 2015). In terms of language, the prefrontal cortex emerges as the highest organiser of language and its grammar (Fuster, 2013). The prefrontal cortex is the so-called *organ of creativity* (Fuster, 1995, 2002). It specialises in the organisation/planning of both novel linguistic sequences and novel action sequences and plays a role in the operations for their expression/production (Fuster, 1995, 1997, 2013, 2015; see also Haber, 2016).

The prefrontal cortex is essential to novel organisations (schemas, plans) that need sustained attention throughout their elaboration; that is, across time (Fuster, 2003, 2015). In the case of language, "*The order of syntax is a temporal order. The speaker or writer provides meaning to sentences by ordering words in the temporal domain*." (Fuster, 2003:206). The purposeful, meaningful expression of language, like the execution of goal-directed action, is preceded by the mental formulation of a broad plan (or schema) of the intended production. (Fuster, 1995, 2003). Then, prefrontal networks interact with semantic networks in the construction of a novel linguistic sequence across time; that is, until the expression of the sequence is completed. In more detail, the prefrontal cortex exerts control over different brain structures in order to sharpen attention, maintain working memory and organise sequences (Fuster, 2003, 2008, 2013, 2015; see also Miller and Cohen, 2001). Working memory is sustained attention (Fuster, 2008, 2015) and becomes a syntactic function: in linguistic syntax, working memory plays its role when attention to words needs to be maintained over time for its integration with subsequent words (Fuster, 2003; 2015). Also, as outlined earlier, a young child produces short, simple utterances (see *two-word utterances* above). This may be due to the existence of limited cognitive resources. Attention and/or working memory are initially limited and increase over time and so children move from short, simple utterances to increasingly complex syntactic forms (Elman, 1999; Owens, 2016). In addition, sequences are often mixed and may contain segments that are novel and unrehearsed as well as segments that are old and thoroughly practised (Fuster, 1995; for old, thoroughly practised sequences, see next section).

Further, the prefrontal cortex is involved in processes of sensorimotor integration. Sensorimotor integration entails the translation of perception into action, including language. This process is dependent on motor areas of the brain, i.e the prefrontal cortex (Fuster, 2000, 2003, 2015). In our daily lives we perceive a wealth of sensory information (i.e. visual, auditory) and only a small part of our sensory impressions leads to action. Our capacity to act on the external world by efficiently gathering and processing sensory information that pertains to different sensory modalities is a fundamental aspect of human cognition and skilled action. Understanding the ability to integrate relevant sensory information devoted to the expression of action is a central issue in the literature of sensorimotor integration (Fuster, 2003; Boutin et al., 2013). Sensorimotor integration involves: (a) gathering and processing sensory information that is relevant to a particular sequence, (b) organising that sequence and (c) expressing it (Wolpert et al, 2011; Velasques et al., 2013). The prefrontal cortex is essential to the integration of sensory information, which is forwarded by sensory areas and comprises mainly the sensory modalities of sight and sound, in the organisation and expression of action sequences, including linguistic sequences (Fuster et al., 2000; Fuster, 2003, 2015).

2.6. Neuroscience: Expression of and chunk-based, routinised sentences (linguistic sequences)

As stated, the basal ganglia are another motor area that is devoted to action (Fuster, 1995, 1997, 2015). The basal ganglia contribute to the acquisition of skills by promoting the recoding of sequences into *motor chunks*, blocks or packages of overlearned sequences. Sequences that are repeated over and over again (that is, that are overlearned, routinised) become chunked by the basal ganglia (Jog et al., 1999; Graybiel, 1998, 2008; Graybiel & Mink, 2009; Boutin et al., 2013). Further, like the prefrontal cortex, the basal ganglia also harbour the rules of action and language (Fuster, 1989, 1995). With practice, the basal ganglia are said to learn, organise and express *motor chunks* in a particular temporal order and in an automatic fashion (Graybiel, 1995, 1998, 2000, 2008; Graybiel & Mink, 2009; Boutin et al., 2013; see also Haber, 2016). Unlike novel sequences, automatic, well-rehearsed sequences need minimal attention (Fuster, 2003). In addition, recoding bits of information into *motor chunks* allows for efficiency in information processing. *Motor chunks* are retrieved faster and more accurately than when dealing with items individually (Graybiel, 1998; Diedrichsen & Kornysheva, 2015). Such chunks are especially relevant for action sequences that need extremely fast and accurate control, such as the sequences of language (Graybiel, 2008; Jin & Costa, 2010, 2015; Jin et al., 2014).

Moreover, automatic, well-rehearsed sequences engage mainly the basal ganglia for sensorimotor integration (Fuster, 1997, 2003, 2015). Neurons in the basal ganglia are highly context-dependent. They integrate and respond to sensory input from different modalities, i.e. visual, auditory (Graybiel, 1995, 2005; Saint-Cyr, 2003, Nagy et al., 2006). Neuroimaging evidence shows that the prefrontal cortex intervenes in the organisation/planning and expression/production of action sequences, together with linguistic sequences, only during the initial stages of learning. Afterwards, as the subject becomes proficient, the basal ganglia become progressively more and more active (Grafton et al., 1992; Jenkins et al., 1994; Fuster, 1997, 2003, 2015). Thus, excluded from the main prefrontal duties are familiar rules and their implementation, overlearned actions, as well as routine language (Fuster, 2015).

2.7. Psychology and neuroscience: Memory, its processes and further related issues

In the previous sections, we observed the three milestones in the acquisition and expression of language. Here, acquisition is tackled in terms of memory processes and further related aspects (i.e. overcoming processing limitations). Memory is the capacity to retain (acquire, learn), retrieve (access) and use information about oneself and one's environment (Fuster, 1995, 2003). Memory entails different processes: encoding, consolidation, and retrieval. First, memories are formed, encoded. Encoding is the process by which we transform perceptions into memories. Further, consolidation is the process by which memories are strengthened, become stable in the brain. Shortly after encoding, memories exist in a fragile state in which they can be easily disrupted; once consolidation has occurred, they are more solid and robust to disruption (McGaugh, 2000; Fuster, 2003; Schacter et al., 2011). The term "consolidation" is attributed to Müller and Pilzecker (1900), who proposed that learning does not induce instantaneous, permanent memories. Instead, memories take time to be fixed, consolidated (Lechner, Squire & Byrne, 1999; Fuster, 2003). Finally, memories are retrieved −accessed, extracted from memory− to be used (Fuster, 2003; Schacter et al., 2011).

Thus, a new experience causes the firing (activation) of a group of neurons. For example, the experience of seeing a yellow rose or a blue ball is the result of the firing of a specialised group of neurons in the visual cortex. In the same vein, a specialised group of neurons firing together in the auditory cortex will result in the experience of listening to a song. The pattern of firing remains encoded in a neuronal network. And so, we can remember the image of the rose or the ball and the melody of the song (Damasio, 1994; Ratey, 2001; Wolfe, 2010). According to Ratey (2001), each time an experience is repeated, the neurons can strengthen their connections; that is to say, the more a neuronal network is reactivated, the more permanent the learning becomes. In Fuster's (2003) words, the strength of a network is dependent on the efficiency of consolidation and repetition, rehearsal and practice contribute to such efficiency. Memories also undergo retrieval. To retrieve a memory means to reactivate the network that defines and sustains a particular memory. In order for a memory to be retrievable (accessed), its network must have a certain degree of strength.

Now, consider the following example. Study (practice, repeat, rehearse) the numbers in the top row (see Fig 1: Howard's Digit Memory Test). Then, close your eyes and, after a couple of seconds, try to say the numbers back in the same order. Then, try the next row, and the one after that, until you make a mistake.

925
8642
37654
627418
0401473
19223530
486854332
2531971768
85129619450
918546942937

Figure 1: Digit Memory Test by Howard (1983, in Bernstein et al., 2008:215).

Most people can listen to or watch a list of numbers and then repeat them as long as the list is no more than about seven items long (Schacter et al., 2011). In performing Howard's Digit Memory Test, we can see that, in the absence of chunking, each item to be retained is processed as a single bit of information, which rapidly floods our processing capacity (i.e. Cacioppo & Freberg, 2013). It has also been argued that we should come up with about the same result whether we use digits, letters, or words (Bernstein & Nash, 2008).

Moreover, in 1956, psychologist Miller studied the limits of *immediate memory*. Note that modern proposals use the term *working memory* instead. As stated, working memory is sustained attention. It is the ability to keep something in mind (Fuster, 2008, 2015; Baars & Gage, 2010). In other words, working memory refers to information that we are currently working on (Gleitman et al., 2011). Immediate memory (or rather, working memory) is limited by the number of items kept in mind, worked on. Prefrontal activation increases depending on the number of items (i.e., words) held in working memory. Whatever the content in working memory is, the amount of prefrontal activation is directly proportional to its cognitive load. A cognitively demanding task (that is, one imposing a great demand on our attentional resources) is the equivalent of juggling half a dozen balls at the same time (Miller, 1956; Fuster, 2009; Baars & Gage, 2010). Also, according to Miller (1956), the span of immediate memory (working memory) constitutes the amount of information that can be retained and retrieved. He also argued that we must recognise the importance of organising input sequences into chunks since a deal of learning involves the formation of such packages. And, he pointed out that language is tremendously useful for repackaging material into chunks.

One research question guided the study: Will the treatment yield an increase in the retrieval (accessibility) and use (expression, production) of the third person singular –s?

3. Material and Methods

3.1 Participants

The present study comprised 64 EFL students, aged 8-11, from three different public schools in Northern Spain. Twenty-five students (12 males, 13 females) from one school in the Basque Autonomous Community (BAC) formed the control group (group 1). Further, 12 (5 males, 5 females) students from a second school in the BAC made up the first experimental group (group 2) and 27 students (12 males and 15 females) from a school in the Foral Community of Navarre formed the second experimental group (group 3).

Moreover, details about the participants' linguistic history were collected by means of a background questionnaire. The study involved access to the participants' classes in order for the researcher to implement the treatment. Before the collection of the data and the implementation of the experiment, the participants' parents and legal guardians signed a consent form. The participants' characteristics are summarised in Table 2.

Table 2: Participant characteristics

Group	N	Age at testing	Age average	Years of exposure	Age of first exposure	Percentage of learners receiving extracurricular lessons	Percentage of learners speaking Basque at home
1	25	8-11	9.52	6.18 (SD 2.27)	3.34 (SD 2.05)	56.00%	84%
2	12	8-11	9.75	6.83 (SD 1.86)	2.92 (SD 0.97)	41.67%	75%
3	27	8-11	9.78	6.96 (SD 1.83)	2.81 (SD 1.38)	44.44%	18%

The three groups differed on several respects: a) the lack or presence of a textbook in their instruction of English b) the total number of hours received in English and c) whether they were bilingual or not. Group 1 and group 2 had no textbook. Yet, group 3 did. Further, group 1 made use of videos, songs and crafts. Group 2 used projects, videos, songs and games. Group 3 employed textbook, games and songs. As for the number of hours received in English at each academic year, group 1 and group 2 had a lower number of hours when compared to group 3. The total number of hours of exposure ranged from 370 to 814 in group 1, from 160 to 400 in group 2, and from 925 to 1480 in group 3. Also, at the time of testing, the youngest students (3rd and 4th year of primary education) from group 3 had received 10 hours of English per week because they were enrolled in PAI (Programa de Aprendizaje en Inglés "Programme to Learn in English"), a variant of CLIL (Content and Language Integrated Learning). By contrast, the oldest students (5th and 6th years of primary education) from group 3 had received 5 hours per week. The total number of hours of exposure is summarised in Table 3.

Table 3: Total number of hours of exposure

Group	N	3 primary (8 years old)	4 primary (9 years old)	5 primary (10 years old)	6 primary (11 years old)
1	25	370	518	666	814
2	12	160	240	320	400
3	27	1110	1480	925	1110

Participants also differed over their knowledge of one or more languages other than English. Despite such differences the participants all had the same level of proficiency in English, as established by the Oxford placement test.

3.2 Materials

The materials used in the present study comprised an Oxford placement test, an oral sentence transformation task and instruction that focused on the 3rd person singular –s and was administered after the pretest. All participants were given the Quick Placement Test (Oxford University Press, ©UCLES, 2001). The experiment consisted of four tasks: two oral production tasks, one written production task and a grammaticality judgement test. All the tasks followed a pretest-postest procedure. In the present paper, only the results obtained in the task of oral sentence transformation (OST) shall be presented. In OST, 64 items were split for the pretest and the postest. Each item consisted of two parts: a lead-in sentence (i.e. *They are living in Rome*) and a key word (i.e. *I*). Participants had to orally produce a sentence that began with the key word and entailed the rephrasing of the lead-in sentence according to the key word, as shown in the examples:

(20) They are living in Rome now.
I ……………………………………….
(21) They are walking to school now.
You …………………………………….
(22) They sing very often.
He ……………………………

Moreover, whereas the control group followed its own school instruction, the two experimental groups followed a treatment that was based on neuroscience and psychology and that integrated innovative pedagogical techniques (©2018, 2019, Verónica Mendoza Fernández): *sensory chunking*, *sensorimotor drilling* and the structuration of linguistic input on the basis of processing demands. *Sensory chunking* is a pedagogical technique that involves learners' repeated perception and expression of chunked sentences. Each of the chunks of a sentence is referred to as a *sensory chunk. Sensory chunks* are cognitively manageable ("easy to deal with") pieces of language that are perceived (listened to and read) and produced (practised, drilled) by learners (see Figure 2).

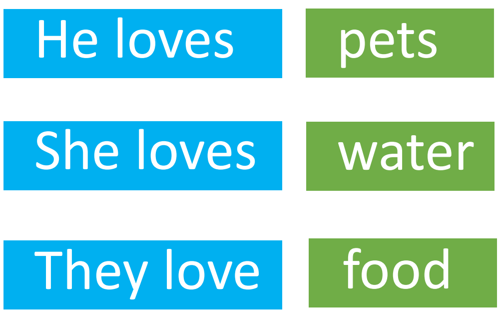

Figure 2: Illustration of three chunked sentences used in the experiment. Each sentence is made up of two sensory chunks (©2018, 2019, Verónica Mendoza Fernández).

Further, *sensorimotor drilling* conveys training in the linguistic reaction to non-linguistic and linguistic stimuli (i.e. the visual representation of objects, actions and emotions; spoken sentences). To that end, linguistic stimuli (vocabulary items and *sensory* *chunks*) were perceived and produced by learners as they watched visual imagery (that is, non-linguistic stimuli) that matched the linguistic stimuli. For an example of visual imagery that was used in the experiment, see ANNEXE, which contains an image from an illustrated tale. The tale portrayed contexts that are expressed in the present simple tense: habits, routines, states and likes.

Further, the treatment structures linguistic input into three instructional stages according to increasing (though cognitively manageable) complexity:

(a) Stage 1 - *Sensorimotor Vocabulary Drilling*. Perception and expression of vocabulary items, i.e. eat. Such words are subsequently reused in stages 2 and 3.
(b) Stage 2 - *Sensorimotor Sentence Drilling I*. Perception and expression of short, simple sentences. This stage consists of two substages: Basic Sequencing and Expansion of Basic Sequencing. Basic Sequencing encompasses the rehearsal of short, chunked sentences, i.e., [He eats] [a lot], [He travels] [a lot]. In Expansion of Basic Sequencing, sentences display a slight increase in the number of *sensory chunks* or words per sentence, i.e., [She eats] [fish] [a lot]; [They travel] [to Italy] [a lot]. For the experiment, all verbs were expressed in the present simple.
(c) Stage 3 - *Sensorimotor Sentence Drilling II*. Perception and expression of sentences that combine "old", Stage-2 sensory chunks ([He travels], [a lot]) with "new", Stage-3 sensory chunks (i.e. [when]), as in the sentence [He eats] [a lot] [when] [he travels] [a lot] in order to further work on chunk-based choice, chunk-based order and combination and chunk-based rule implementation.

In the literature review, three milestones in language acquisition and expression were outlined: (1) acquisition and expression of vocabulary, (2) expression of linguistic sequences that need attention to words throughout their elaboration (in other words, cognitively demanding sequences) and (3) expression of automatic, routinised, chunk-based linguistic sequences that require minimal attention throughout their elaboration. Also, in the literature review, we saw that early sentences contain very few words, that some chunks begin to emerge at an early stage of language acquisition and that, eventually, proficiency in the skill of language requires linguistic sequences that are built from "the chunks of the brain" (*motor chunks*).

As a result, instructional stage 1 involved the repeated perception and expression of vocabulary items and both instructional stages 2 and 3 entailed the repeated perception and production of *sensory chunks* and worked on chunk-based choice, chunk-based order and combination and chunk-based rule implementation. Further, given the cognitively demanding nature of milestone (2) and the automatic, chunk-based nature of milestone (3), chunked sentences (and, therefore, *sensory chunks*) were used throughout both instructional stages 2 and 3. Additionally, the structuration of linguistic input according to increasing (though cognitively manageable) complexity also entailed: (a) a gradual increase in the number of linguistic pieces (vocabulary items and *sensory chunks*) to be perceived and produced per utterance across stages and substages (see *Basic Sequencing* and *Expansion of Basic Sequencing*, as substages of *Sensorimotor Sentence Drilling I* above) and (b) reusing linguistic pieces from previous instructional stages and substages, which allowed learners to rehearse an increasing number of organisations and combinations of *sensory chunks* ─including those *sensory chunks* on which rules are stamped, i.e. [He loves]─.

3.3 Procedure

In week 1 the participants were given the pretest tasks. In week 2, learners in the three groups received three classes that focused on the -s of the present simple and lasted 45 minutes each (total: 2 hours 15 minutes). Learners from group 1 received their own school instruction. By contrast, learners from groups 2 and 3 were administered the treatment of the third person singular –s designed by the author of the present manuscript. In week 3, learners carried out the postest tasks.

3.4 Codification

Descriptive and inferential statistical analyses were carried out using SPSS (version 25). Given the aforementioned differences between groups, and given the fact that the data did not meet the required normal distribution and homoscedasticity, the Wilcoxon non-parametric tests were used to compare the improvement in the retrieval (accessibility) and use (expression, production) of the -s of the present simple tense from pretest to postest within groups. As mentioned earlier, although only the results of OST are presented here, the experiment consisted of four tasks. Each task involved a different number of items used for the testing of the -s. To even the results of the four tasks that formed the experiment, the scores were calculated over 100, which yielded the percentage of retrieval and use of the -s in each task. Moreover, for the four tasks, the scores calculated over 100 were then grouped into four intervals that had the same width and, therefore, conveyed the information corresponding to the quartiles. Further, the information was expanded by including the minimum (0) and maximum (100) scores.

4. Results and Discussion

Here are the results of the retrieval (accessibility) and use (expression, production) of the required item (the -s of the present simple tense) in OST. Both the mean and the median increased significantly for groups 2 and 3 in the postest (Table 4).

Table 4: Correct sentence transformations in OST

Group	N	Pretest				Postest			
		Mean	Median	SD	CI	Mean	Median	SD	CI
1	25	1.40	0.00	7.000	[-1.49/4.29]	6.00	0.000	15.676	[-.471/ 12.471]
2	12	**3.75**	**0.00**	10.028	[-2.62/10.12]	**47.73**	**43.182**	38.496	[23.268/72.187]
3	27	**14.63**	**5.00**	21.791	[6.01/23.25]	**60.10**	**72.727**	32.026	[47.432/72.769]

The Wilcoxon Test showed statistical differences in the two experimental groups only. Group 2 increased the percentage of retrieval and use of the -s of the present simple tense in the postest (Z=-2.756, p=0.006; d_{Cohen}=2.626, which showed a large magnitude of effect sizes). So did group 3 (Z=-4.571, p=0.000; d_{Cohen}=3.7, which also showed a large magnitude of effect sizes).

Here are the data corresponding to the analysis of the intervals of retrieval and use of the required item (the -s of the present simple tense) in OST:

GROUP 1. In the pretest, all the participants obtained a percentage of retrieval and expression of the required item that was <50.00%. In the postest, still 23 participants (92% of the sample) scored a percentage that was <50.00%. In more detail, and with respect to the minimum scores, 24 participants (96% of the sample) and 21 participants (84% of the sample) obtained the score 0.00% of accessibility to and expression of the required item in the pretest and postest, respectively. No participants reached the maximum in the pretest or postest.

GROUP 2. In the pretest, all the participants scored a percentage of retrieval and expression of the required item (that is, the 3rd person singular -s) that was <50.00%. Out of them, 11 participants (91.7% of the sample) obtained results ≤25.00%. In the postest, 7 participants (58.3% of the sample) accessed and produced the -s <50.00%. Out of these 7 participants, 4 (33.3% of the sample) obtained results ≤25.00%. Also, in the postest, 5 participants (41.6% of the sample) obtained results ≥50.00%. Out of these 5 participants, 4 (33.3% of the sample) obtained results ≥75.00%. In further detail, and in terms of the minimum and maximum scores, 9 participants (75% of the sample) and 2 participants (16.7% of the sample) scored 0.00% of retrieval and use of the required item in the pretest and postest, respectively and, additionally, 1 participant (8.3% of the sample) obtained the maximum score (100%) in the postest only.

GROUP 3. In the pretest, 25 participants (92.6% of the sample) were able to access and produce the required item <50.00%. Out of them, 21 participants (77.8% of the sample) obtained results ≤25.00. Furthermore, 2 participants (7.4% of the sample) obtained results ≥50.00%. Out of them, 1 participant (3.7% of the sample) obtained results ≥75.00%. In the postest, 11 participants (40.7% of the sample) were able to retrieve and express the required item <50.00%. Out of these 11 participants, 5 (18.5% of the sample) obtained results ≤25.00. Also, in the postest, 16 participants (59.2% of the sample) accessed and expressed the required item ≥50.00%. Out of these 16 participants, 11 (40.7% of the sample) obtained results ≥75.00%. In more detail, and with respect to the minimum and maximum scores, 11 participants (40.7% of the sample) obtained the score 0.00% of retrieval and production of the required item in the pretest but no participants obtained that score in the postest. Additionally, 4 participants (14.8% of the sample) reached the maximum score (100%) in the postest only (Table 5).

Table 5: OST. Retrieval and use of the required item

Percentage of retrieval and use of the required item	Group 1		Group 2		Group 3	
	PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners	PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners	PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners
≤25.00%	24 (96.0%)	23 (92.0%)	11 (91.7%)	4 (33.3%)	21 (77.8%)	5 (18.5%)
25.00-49.99%	1 (4.0%)	-	1 (8.3%)	3 (25.0%)	4 (14.8%)	6 (22.2%)
50.00-74.99%	-	2 (8.0%)	-	1 (8.3%)	1 (3.7%)	5 (18.5%)
≥75.00%	-	-	-	4 (33.3%)	1 (3.7%)	11 (40.7%)

Thus, despite the brief implementation of the treatment (2 hours and 15 minutes), the results showed that the degree of retrieval and use of the required item, understood as a piece retained in memory, varied from pretest and postest: it increased only for participants in groups 2 and 3. In such groups, there was:

- a decrease in the percentage of learners scoring results <50.00%, including the prevailing score 0.00% (see above);
- an increase in the percentage of learners obtaining results ≥75.00%.

Further, the four intervals having the same width and reflecting the quartiles, were labelled by the author of the manuscript in terms of the degree of accessibility to and expression of the required item, as shown in Table 6:

Table 6: Degree of retrieval (accessibility) and use (expression/production) of the required item

Percentage of retrieval and use of the required item	Degree of retreival and use of the required item
≤25.00%	Very low
25.00-49.99%	Low
50.00-74.99%	Moderate
≥75.00%	High

Therefore, in the postest, there was:

- a decrease in the percentage of learners displaying a (very) low degree of retrieval and use of the required item, including a decrease in the pervasive score 0.00% of accessibility to and expression of the required item (see above);
- an increase in the percentage of learners displaying a high degree of retrieval and use of the required item (see Table 7).

Table 7: OST. Degree of retrieval and use of the required item

Percentage of retrieval and use of the required item	Degree of retrieval and use of the required item	Group 1		Group 2		Group 3	
		PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners	PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners	PRETEST Number (Percentage) of learners	POSTEST Number (Percentage) of learners
≤25.00%	Very low	24 (96.0%)	23 (92.0%)	11 (91.7%)	4 (33.3%)	21 (77.8%)	5 (18.5%)
25.00-49.99%	Low	1 (4.0%)	-	1 (8.3%)	3 (25.0%)	4 (14.8%)	6 (22.2%)
50.00-74.99%	Moderate	-	2 (8.0%)	-	1 (8.3%)	1 (3.7%)	5 (18.5%)
≥75.00%	High	-	-	-	4 (33.3%)	1 (3.7%)	11 (40.7%)

As mentioned, learning (acquisition, retention) does not induce instantaneous, permanent memories. Instead, memories take time to be fixed, consolidated (Lechner, Squire & Byrne, 1999; Fuster, 2003). Consolidation is the process by which memories are strengthened (McGaugh, 2000; Fuster, 2003; Schacter et al., 2011). Further, in order for a memory to be retrievable/accessed, its network must have a certain degree of strength. Repetition, rehearsal and practice work in the strengthening of memories, of the networks harbouring such memories (Fuster, 2003). Thus, the percentage of retrieval and accurate use of the present simple -s is also indicative of the degree of strength of the required piece of information: the 3rd person singular -s. And, as evidenced by the rise in the degree of retrieval and expression of the required item, the treatment did increase the degree of strength of the -s. Therefore, the treatment improved the retention (acquisition, learning), strengthening (overlearning), and retrieval of (accessibility to) a piece of linguistic information ‒here, the -s of the present simple‒.

5. Conclusion

The aim of this paper was to present the results of a treatment that was applied to the -s of the present simple tense. One research question guided this study: Will the treatment yield an increase in the retrieval (accessibility) and use (expression, production) of the third person singular –s? The Wilcoxon Test showed statistical differences only in the two experimental groups (groups 2 and 3), where the treatment was implemented. Despite the initial differences between such groups (see section 3), the treatment exerted a unifying influence on both of them. And so, Group 2 increased the percentage of retrieval and use of the -s of the present simple tense in the postest ($Z=-2.756$, $p=0.006$; $d_{Cohen}=2.626$, reflecting a large magnitude of effect sizes), which was true of group 3 ($Z=-4.571$, $p=0.000$; $d_{Cohen}=3.7$, also showing a large magnitude of effect sizes).

The treatment was characterised by the integration of pedagogical techniques that had been derived from the fields of neuroscience and psychology: *sensorimotor drilling*, the structuration of linguistic input on the basis of processing demands and *sensory chunking*. *Sensorimotor drilling* is a form of pedagogical training in the linguistic reaction to both non-linguistic and linguistic stimuli (i.e. representations of objects, actions, states and emotions that can be watched; spoken sentences that can be listened to). *Sensorimotor drilling* seeks that learners can translate their outer and inner worlds into language and, additionally, can interact with other speakers through language. To that end, this form of rehearsal and practice comprises, on the one hand, learners' repeated perception of visual imagery that represents particular contexts (i.e. habits, routines, states and likes) and, on the other hand, learners' repeated perception and production of linguistic stimuli (here, vocabulary items and chunked sentences). The linguistic stimuli match the non-linguistic stimuli perceived (that is, the visual imagery). In short, in *sensorimotor drilling*, linguistic stimuli are listened to, read and rehearsed/practised/drilled in relation to contextualised visual imagery.

Further, the treatment comprises three instructional stages: *Sensorimotor Vocabulary Drilling*, *Sensorimotor Sentence Drilling I* (which includes the substages of *Basic Sequencing* and *Expansion of Basic Sequencing*) and *Sensorimotor Sentence Drilling II*. *Sensorimotor Vocabulary Drilling* pivots on learners' repeated perception and production of vocabulary items. Both *Sensorimotor Sentence Drilling I* and *II* hinge on learners' repeated perception and expression of chunked sentences and work on chunk-based choice, chunk-based order and combination and chunk-based rule implementation. In addition, *sensory chunking* is a pedagogical technique that refers to the repeated perception and repeated expression of chunked sentences. Each of the chunks of a sentence is referred to as a *sensory chunk.* A sensory chunk is a building block of language that may consist of one or several words. A *sensory chunk* can be listened to, read and drilled. Further, a *sensory chunk* is a cognitively manageable ("easy to deal with") piece of language. *Sensory chunks* (including those containing the -s of the present simple, i.e. [He loves]) formed the linguistic input used to teach the present simple -s throughout instructional stages 2 and 3.

Moreover, the treatment involves the structuration of linguistic input according to increasing −though cognitively manageable− complexity. The three aforementioned instructional stages were devised to respect the landmarks in language acquisition and expression reported by psychologists, as well as complementary evidence supplied by neuroscientists. In the literature review, evidence of three milestones in language acquisition and expression comprised: (1) acquisition and expression of vocabulary (semantic memory), (2) expression of cognitively demanding linguistic sequences that require attention to words throughout their elaboration and (3) expression of automatic, well-rehearsed, chunk-based linguistic sequences that need minimal attention throughout their elaboration. Also, in the literature review, it was highlighted that early sentences are short, that some chunks begin to occur at an early stage of language acquisition and that, eventually, proficiency in language requires linguistic sequences that are built from *motor chunks* ("the chunks of the brain"). Therefore, given the cognitively demanding nature of milestone (2) and the automatic, chunk-based nature of milestone (3), chunked sentences (and hence *sensory chunks*) were used throughout both instructional stages 2 and 3. Further, the structuration of linguistic input according to increasing (though cognitively manageable) complexity also entailed: (a) a gradual increase in the number of linguistic pieces (vocabulary items and *sensory chunks*) to be perceived and produced per utterance across stages and substages (see, for example, *Basic Sequencing* and *Expansion of Basic Sequencing*, as substages of *Sensorimotor Sentence Drilling I* in section 3) and (b) reusing, and hence "re-drilling", words from previous instructional stages and substages, including those *sensory chunks* on which rules, such as the -s of the present simple tense, are stamped.

What is more, in terms of memory, it was pointed out that learning (acquisition, retention) does not induce instantaneous, permanent memories and memories take time to be fixed, consolidated (Lechner, Squire & Byrne, 1999; Fuster, 2003). Yet, repetition, rehearsal and practice work in the strengthening of memories, of the networks sustaining such memories (Fuster, 2003). The treatment discussed here was aimed at maximising classroom time. Drilling was highly condensed, very concentrated in the time available, in attempt to make the -s robust, solid and permanent in memory ━in other words, in an attempt to increase its degree of strength and, hence, its degree of retrieval and use━. The degree of strength of the -s varied from pretest and postest: it increased in the two experimental groups only, after the implementation of the treatment, as evidenced by the rise in the degree of retrieval (accessibility) and use (expression, production).

It must be also underscored that the treatment was implemented to efficiently teach the 3rd person singular -s and, also, contribute to language teaching and automatisation. By 'automatisation', the author of the manuscript refers to the process that comprises the retention (acquisition, learning), strengthening (overlearning) and retrieval (access) of linguistic memories for their automatic organisation and expression (that is, for their effortless, accurate, fast planning and production) in response to particular contexts. In terms of automatisation, *sensorimotor drilling* conveys the perception and production of the chunk-based organisation/planning and expression/production of linguistic sequences in response to context-related sensory information, stimuli. With practice, such linguistic expressions could become automatised, overlearned, chunk-based reactions to particular non-linguistic and linguistic stimuli. As outlined in the introduction, *sensorimotor drilling* is a pedagogical strategy that attempts to transfer the concept of *sensorimotor integration* to classroom practice. *Sensorimotor integration* refers to the process that transforms perception into action or language in the brain (Fuster, 2003). *Sensorimotor integrations* that are dependent on the basal ganglia are those that are associated with the proficiency in and automaticity of a skill (i.e. Fuster, 2003, 2015) and those that imply the chunk-based organisation and expression of sequences in response to particular contexts (i.e. Graybiel, 1995, 1998, 2005).

Therefore, on the basis of the results concerning the -s of the present simple, the author suggests that the treatment, including *sensory chunks*, can contribute to the acquisition and strengthening of the -s of the present simple tense. Moreover, on the basis of the results concerning the -s of the present simple, together with evidence from the literature review presented above (i.e. Miller, 1956; Howard, 1983; Graybiel 1995, 1998, 2005, 2008; Jin & Costa, 2010, 2015; Jin et al., 2014), the author suggests that the pedagogical strategies agglutinated by the treatment, mainly *sensory chunks*, may well contribute to the acquisition and strengthening of *motor chunks*, needed for the automatic organisation and expression of language in response to context-related sensory information. More precisely, the implementation of the integrative pedagogy throughout a wider timespan (not just the 2 hours and 15 minutes allotted for the current experiment) could well contribute to the retention (acquisition, learning) and strengthening (overlearning) of *motor chunks*. Once overlearned, "the chunks of the brain" could be effortlessly, fast and accurately retrieved for the automatic planning and production of language in response to contextualised stimuli.

Acknowledgements
Dr. Maria Juncal Gutierrez Mangado (University of the Basque Country, Spain) provides academic support and contacted two of the schools where the data for the current experiment were collected.

About the Author(s)
Verónica Mendoza Fernández is a PhD student supervised by Dr. Maria Juncal Gutierrez Mangado. Verónica holds an MA in Linguistics Applied to the Teaching of English as a Foreign Language. She is currently working as a research assistant at LASLAB (Language and Speech Laboratory) in the University of the Basque Country (Spain). Her interests comprise: automatisation; application of neuroscience and psychology to pedagogy; elaboration of teaching materials.

References

[1] Aaronson D, Scarborough H S, 1977. Performance theories for sentence coding: Some quantitative models. Journal of Verbal Learning and Verbal Behavior 16(3): 277–303. doi: 10.1016/S0022-5371(77)80052-2
[2] Baars B J, Gage N M, 2010. Cognition, Brain, And Consciousness: Introduction to Cognitive Neuroscience. 2 edn. MA, USA
[3] Bernstein D A, Nash P W, 2008. Essentials of Psychology. MA, USA
[4] Boloh Y, Champaud C, 1993. The past conditional verb form in French children: The role of semantics in late grammatical development. Journal of Child Language 20: 169–189. doi: 10.1017/S0305000900009181
[5] Boutin A, Massenand C, Heuer H, 2013. Modality-specific organization in the representation of sensorimotor sequences. Frontiers in Psychology 4: 937, doi: 10.3389/fpsyg.2013.00937
[6] Bybee J, 2010. Language, usage and cognition. NY, USA
[7] Braine M D S, 1976. Children’s first word combinations. Monographs of the Society for Research in Child Development 41(1, Serial No. 164). doi: 10.2307/1165959
[8] Brown, 1973. A first language: The early stages. MA, USA
[9] Bukatko D, Daehler M V, 2014. Child Development: A thematic approach. 5 edn. MA, USA
[10] Cacioppo J T, Freberg L A, 2013. Discovering Psychology: The Science of Mind. CA, USA
[11] Damasio A, 1994. Descartes’ error: Emotion, reason, and the human brain. NY, Grosset Putnam
[12] Diedrichsen J, Kornysheva K, 2015. Motor skill learning between selection and execution. Trends in Cognitive Sciences 19: 227–233. doi: 10.1016/j.tics.2015.02.003

[13] Elman J L, 1999. The emergence of language: A conspiracy theory. In B. MacWhinney, The emergence of language, pp 1–27
[14] Elman J L, 1993. Learning and development in neural networks: the importance of starting small. Departments of Cognitive Science and Linguistics, University of California, USA. doi: 10.1016/0010-0277(93)90058-4
[15] Clark E V, 2009. First Language Acquisition. 2 edn. Cambridge, UK
[16] Fernandez E M, Cairns H S, 2011. Fundamentals of Psycholinguistics. Oxford, UK
[17] Fuster J M, 2015. The Prefrontal Cortex. 5th edn. London, UK
[18] Fuster J M, 2013. The Neuroscience of Freedom and Creativity. Cambridge, UK
[19] Fuster J M, 2009. Cortex and memory: emergence of a new paradigm. Journal of Cognitive Neuroscience 21: 2047–2072. doi: 10.1162/jocn.2009.21280
[20] Fuster J M, 2008. The Prefrontal Cortex. 4th edn. London, UK
[21] Fuster J M, 2003. Cortex and Mind: Unifying Cognition. NY, USA
[22] Fuster J M, 1997. Network memory. Trends Neuroscience 20: 451–459. doi: 10.1016/S0166-2236(97)01128-4
[23] Fuster J M, 1995. Memory in The Cerebral Cortex. London, UK
[24] Fuster J M, 1989. The Prefrontal Cortex: Anatomy, Physiology, and Neuropsychology of the Frontal Lobe. 2nd edn. NY, USA
[25] Fuster J M, Bodner M, Kroger J K, 2000. Cross-modal and cross-temporal association in neurons of frontal cortex. Nature 405(6784): 347–351 doi: 10.1038/35012613
[26] García Mayo M P, Villarreal Olaizola I, 2011. The development of suppletive and affixal tense and agreement morphemes in the L3 English of Basque-Spanish bilinguals. Second Language Research 27(1): 129-149. doi: 10.1177/0267658310386523
[27] Gleitman H, Gross J, Reisberg D, 2011. Psychology. 8 edn. London, UK
[28] Grafton S T, Mazziotta J C, Woods R P, and Phelps M E, 1992. Human functional anatomy of visually guided finger movements. Brain 115: 565-587. doi: 10.1093/brain/115.2.565
[29] Graybiel A M, 2008. Habits, Rituals, and the Evaluative Brain, 2008. Annual Review of Neuroscience 31:359-387. doi: 10.1146/annurev.neuro.29.051605.112851
[30] Graybiel A M, 2005. The basal ganglia: learning new tricks and loving it. Current Opinion in Neurobiology 15:638–644. doi: 10.1016/j.conb.2005.10.006
[31] Graybiel A M, 2000. The Basal Ganglia. Primer 10(14):PR509-R511. doi: 10.1016/S0960-9822(00)00593-5
[32] Graybiel A M, 1998. The basal ganglia and chunking of action repertoires. Neurobiology of learning and memory 70: 119-136. doi: 10.1006/nlme.1998.3843
[33] Graybiel A M, 1995. Building action repertoires: memory and learning functions of the basal ganglia. Curr Opin Neurobiol 5(6):733-741. doi:10.1016/0959-4388(95)80100-6

[34] Graybiel A M, Mink J W, 2009. The basal ganglia and cognition. The cognitive neurosciences. Massachusetts Institute of Technology, pp 565–585.
[35] Haber S N, 2016. Corticostriatal circuitry. Dialogues in clinical neuroscience 18(1): 7–21. doi: 10.1007/978-1-4939-3474-4_135
[36] Harris J, 1990. Early Language Development. NY, USA
[37] Hoff E, 2014. Language Development. 5th edn. CA, USA
[38] Howard, D.V. (1983). Cognitive psychology. NY, USA
[39] Ingram D, 1989. First Language Acquisition. Method, Description, and Explanation. Cambridge, UK
[40] Ionin T, Wexler K, 2002. Why is 'is' easier than '-s'? Acquisition of tense/agreement morphology by child second language learners of English. Second Language Research 18(2): 95–136. doi: 10.1191/0267658302sr195oa
[41] Jenkins I H, Brooks D J, Nixon P D, Frackowiak R S, Passingham R E, 1994. Motor sequence learning: a study with positron emission tomography. Neurosci 14(6): 3775–3790. doi: 10.1523/JNEUROSCI.14-06-03775.1994
[42] Jin X, Costa R M, 2015. Shaping Action Sequences in Basal Ganglia Circuits. Curr Opin Neurobiol 33: 188–196. doi:10.1016/j.conb.2015.06.011
[43] Jin X, Costa R M, 2010. Start/stop signals emerge in nigrostriatal circuits during sequence learning. Nature 466(7305): 457–462. doi: 10.1038/nature09263
[44] Jin X, Tecuapetla F, Costa R M, 2014. Basal Ganglia Subcircuits Distinctively Encode the Parsing and Concatenation of Action Sequences. Nat Neurosci 17(3): 423-30. doi: 10.1038/nn.3632
[45] Jog M S, Kubota Y, Connolly C I, Hillegaart V, Graybiel A M, 1999. Building neural representations of habits. Science 286:1745-1749. doi: 10.1126/science.286.5445.1745
[46] Kolb B, Whishaw I Q, 2015. Fundamentals of Human Neuropsychology. 7 edn. NY, USA
[47] Lázaro Ibarrola A, García Mayo M P, 2012. L1 use and morphosyntactic development in the oral production of EFL learners in a CLIL context. International Review of Applied Linguistics 50: 135–160. doi: 10.1515/iral-2012-0006
[48] Lechner, Squire & Byrne, 1999. 100 Years of Consolidation−Remembering Müller and Pilzecker. Learn Mem 6(2):77-87. doi: 10.1101/lm.6.2.77
[49] Martínez Adrián M, Gallardo del Puerto F, Gutiérrez Mangado M J, 2013. Phonetic and Syntactic transfer effects in the English interlanguage of Basque/Spanish bilinguals. Vigo International Journal of Applied Linguistics (VIAL) 10: 51-84.
[50] Martínez Adrián M, Gutierrez Mangado, M J, 2015. Is CLIL instruction beneficial both in terms of general proficiency and specific areas of grammar? Journal of Immersion and Content-Based Language Education 3(1): 51-76. doi: 10.1075/jicb.3.1.03adr

[51] McGaugh J L, 2000. Memory: A century of consolidation. Science 287, 248–251. doi: 10.1126/science.287.5451.248

[52] Miller E K, Cohen J D, 2001. An integrative theory of prefrontal cortex function. Annu. Rev Neurosci 24: 167–202. doi: 10.1146/annurev.neuro.24.1.167

[53] Miller G A, 1956. The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychological Review 63(2): 81–97. doi: 10.1037/h0043158

[54] Nagy A, Eördegh G, Paróczy Z, Márkus Z, Benedek G, 2006. Multisensory integration in the basal ganglia. The European Journal of Neuroscience 24(3):917-924. doi: 10.1111/j.1460-9568.2006.04942.x

[55] Nelson K, 1973. Structure and strategy in learning to talk. Monographs of the Society for Research in Child Development 38(1–2, Serial No. 149), 136. doi: 10.2307/1165788

[56] Müller G E, Pilzecker A, 1900. Experimentelle Beiträge zur Lehre vom Gedächtnis. Zeitschrift fur Psychologie Ergänzungsband 1: 1–300

[57] Owens R E Jr, 2016. Language Development: An Introduction. 9th edn. Essex, UK

[58] Peters A M, 1986. Early syntax. In P. Fletcher & M. Garman (Eds.), Language acquisition. 2nd edn. Cambridge, UK, pp 307–325

[59] Peters A M, 1983. The Units of Language Acquisition. Cambridge, UK

[60] Ratey J J, 2001. A User's Guide to the Brain: Perception, Attention, and the Four Theaters of the Brain. NY, USA

[61] Saint-Cyr J A, 2003. Frontal-striatal circuit functions: Context, sequence, and consequence. Journal of the International Neuropsychological Society 9: 103–127. doi: 10.1017/S1355617703910125

[62] Schacter D L, Gilbert D T, Wegner D M, 2011. Psychology. 2 edn. NY, USA

[63] Shaffer D R, Kipp K, 2014. Developmental Psychology: Childhood and Adolescence. 9th edn. CA, USA

[64] Sherwood L, 2012. Fundamentals of Human Physiology. 4 edn. CA, USA

[65] Tomasello M, 2003. A Usage-Based Theory of Language Acquisition. London, UK

[66] Valian V, 1986. Syntactic categories in the speech of young children. Developmental Psychology 22, 562–579. doi: 10.1037/0012-1649.22.4.562

[67] Velasques B, Cagy M, Piedade R, Ribeiro P, 2013. Sensorimotor Integration and Attention: An Electrophysiological Analysis. Functional Brain Mapping and the Endeavor to Understand the Working Brain, chapter 1. doi: 10.5772/55199

[68] White L, 2003. Fossilization in steady state L2 grammars: Persistent problems with inflectional morphology. Bilingualism: Language and Cognition 6:129-141. doi: 10.1017/S1366728903001081

[69] Whitehead M, 2007. Developing Language and Literacy with Young Children. 3rd edn. London. UK

[70] Wolfe P, 2010. Brain Matters: Translating Research into Classroom Practice. 2nd edn. MA, USA

[71] Wolpert D, Diedrichsen J, Flanagan J, 2011. Principles of sensorimotor learning. Nat Rev Neurosci 12, 739–751. doi: 10.1038/nrn3112

[72] Wray A, 2002. Formulaic Language and the Lexicon. Cambridge, UK

ANNEXE – Example of *sensory chunking* in an illustrated tale, *Tim's story,* used in the aforementioned experiment (©2018, 2019, Verónica Mendoza Fernández).