Vocabulary acquisition by young Greek learners of L2 English The predictive role of Complex Working Memory in Early Foreign Language Learning

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Abstract
The article reports the results of a longitudinal research that took place during 2010-12 in two primary schools in Thessaloniki. It is part of a larger research which explored the cognitive impact of Early Foreign Language Learning (EFLL), in relation to Foreign Language (FL) Aptitude, Phonological Short-term Memory (PSTM) and Complex Working Memory (CWM). The findings suggest that EFLL has a boosting effect on children's cognitive skills, while the critical predictor of early FL vocabulary performance is the central executive of Working Memory.

Keywords: Early Foreign Language Learning, Complex Working Memory

1. Introduction

The present article reports the findings of a longitudinal study that took place during 2010-12 to investigate the cognitive impact of instructed EFLL on young Greek learners (from 6 to 8 years of age) (Efstathiadi 2013). To the best of my knowledge, only the linguistic and affective outcomes of EFLL have been extensively explored (García Lecumberri & Gallardo 2003; Mihaljevic Djigunovic & Krevelj 2009; Mihaljevic Djigunovic & Lopriore 2010; Muñoz 2006, 2010; Nikolov 2009).

EFLL has been investigated in relation to FL aptitude (Alexiou 2005; Efstathiadi 2014). Alexiou (2005) reports a strong relation between memory, analytic thought, phonological skills and FL achievement. Efstathiadi (2014) suggests that the early and intensive exposure of 6-year-olds to L2 English enhances their associative memory, inductive reasoning, and overall cognitive capacity. Quite recently, the SLA research has focused on the executive function of WM and, in particular, on the predictive role of Phonological Short Term Memory (PSTM) (Masoura & Gathercole 1999) in FL vocabulary acquisition.

Selected Papers of the 21st International Symposium on Theoretical and Applied Linguistics (ISTAL 21), 527-547
2016, ISSN 2529-1114,

The present study aims to a) record the FL vocabulary performance of the young participants after their two-year intensive exposure to L2 English, b) examine the positive effects of EFLL on the cognitive constructs of PSTM and CWM (i.e. verbal WM), and c) investigate whether, at this early stage, PSTM is the sole predictor of FL vocabulary achievement.

Sections 2 and 3 provide the theoretical outline of the research while sections 4 to 8 include the study methodology, the research questions, the data analysis, the discussion of the findings and some conclusive remarks.

2. Early Foreign Language Learning

Recently, teaching FLs to young learners is gaining popularity all over the world, driven by a) 'the younger the better in the long run' view of Singleton (1995), b) neurobiological accounts (Lenneberg 1967; Peal & Lambert 1962) which propose that learning a language (L1, L2 or FL) is at its highest peak between the ages of 6-9, c) the hightened motivation of young learners (Nikolov 2000), d) their low affective filter (Krashen 1981), and e) their ability to learn implicitly through play-like activities (Johnstone 2009).

Instructed EFLL clearly differs from child SLA in a bilingual context (Muñoz 2010) as far as the quantity and quality of input is concerned. In instructed EFLL, exposure to the FL is limited to the school context as this is not the language of the community, while in child SLA exposure to more than one language is regular and continued. Consequently, younger FL learners need more time than their SL counterparts to learn the language (Nikolov & Mihaljevic Djigunovic 2006). The age effect on FLL is well-documented, with adult FL learners outperforming young children in the short-run due to their advanced cognitive skills (Cenoz 2003; García Lecumberri & Gallardo 2003; Muñoz 2006). However, Muñoz (2010) holds that in the long term young learners can benefit from an early exposure, if they are substantially and intensively exposed to the FL throughout their FL schooling. Therefore, it is clear that the goal of EFLL is not purely a linguistic one. EFLL primarily aims at developing positive attitudes in young learners towards languages and language learning, which will eventually help them become proficient FL users as adults (Nikolov & Mihaljevic Djigunovic 2006).

Recently, an earlier start is strongly being promoted in the EU by the Council of Europe and the European Commission (see Csapó & Nikolov 2009), with the ultimate aim of establishing and further developing plurilingual citizens (Blondin et al. 1998). Projects such as *ELLiE* (Early Language Learning in Europe) seek to find out the realistic achievements of EFLL in European state schools. The findings so far demonstrate an overall positive attitude of teachers and parents (Tragant 2010), an initial heightened learner motivation, yet a very mixed pattern regarding teacher qualifications and the time devoted to FL teaching across Europe (Krikhaar & Lopriore 2010).

3. Working Memory (WM)

In everyday life we often hold pieces of information in mind for short periods of time while doing some other parallel activity. This flexible capacity to store and process information in real time is called *working memory* and is extremely important for our effective cognitive functioning. WM has been viewed as a gateway to long-term memory (LTM) because what is being worked on in the former may become part of the latter (Gathercole & Alloway 2008). Research findings suggest that children's WM capacities undergo a remarkable increase (a two- to three-fold expansion) between 4-14 years of age (Gathercole 1999).

Over the past years WM research has critically influenced SLA research. This is not without explanation. Unlike the automatic and implicit nature of L1 acquisition, SLA is an explicit, controlled, more effortful and attention-demanding procedure (Randall 2007; Schmidt 2001) in terms of cognitive processing and highly prone to failure, due to memory overload or age.

3.1 The WM model of Baddeley and Hitch

Today, the most widely accepted model of WM is that of Baddeley and Hitch (1974). This views WM as a 'flexible mental workspace' of limited capacity (Gathercole & Alloway 2008: 16), where incoming information is stored, processed and manipulated via executive control processes.

According to the model, the *central executive* is a domain-general system (Baddeley 2003) that performs a range of high-level regulatory executive functions, such as directing attention, planning actions, solving problems, etc. (Baddeley 1986).

It supervises the workings of three sub-systems, namely *the phonological loop*, *the visuospatial sketchpad* and *the episodic buffer* (Baddeley 2000) and generally organises the operation of WM. Depending on the task demands, it integrates information from the subsystems and LTM and allocates cognitive resources accordingly.

The *phonological loop* encodes, manipulates all speech-based material, and stores unfamiliar sound patterns, while more stable and detailed phonetic representations are being constructed in LTM (Baddeley, Gathercole & Papagno 1998). It consists of a passive *short-term phonological store* that holds material in a phonological code for 1.5-2 seconds before this fades, unless it is refreshed by *subvocal rehearsal*. The loop also registers visual information in the store, provided this is silently articulated (Baddeley 2003; Sáfár & Kormos 2008). The *visuo-spatial sketchpad* stores incoming material in terms of visual and spatial features while the *episodic buffer* combines all kinds of sensory information (visual, verbal) into unitary and coherent episodes and links them to multidimensional representations in LTM (Alloway et al. 2004).

The capacity of the systems is limited by the amount of information that can be stored before it is lost and the amount of time the input is available for processing. Very often, during complex cognitive tasks, a trade-off relationship occurs: when the resource devoted to processing is great, the other, dedicated to storing its products, becomes less (Baddeley 2007; Daneman & Carpenter 1980).

3.2 WM and (foreign) language learning

Miyake and Friedman (1998) and Skehan (2002) proposed that WM for language should be equated with FL aptitude as their processing stages share a lot in common. This idea has found an overwhelming support (Chan, Skehan & Gong 2011; Dörnyei 2005; Sawyer & Ranta 2001). However, Robinson (2001) and Randall (2007) focus more on the role attended processing plays in establishing new language and memory skills, an extremely important skill in FLL, because of the conscious effort this process entails: language routines become automatic through a directed and targeted repetition of key language patterns that takes place within WM. Thus, a large and efficient WM makes possible the noticing of important aspects in the language input (Robinson 2005) and further facilitates a deeper processing of meaning and form (Hummel & French 2010).

PSTM plays a central role in L1 child and L2 child/adult vocabulary development (Adams & Gathercole 1996; Baddeley et al. 1998; Cheung 1996; Gathercole & Baddeley 1993; Masoura & Gathercole 1999; Μασούρα, Gathercole & Μπαμπλέκου 2004; Papagno, Valentine & Baddeley 1991) and general scholastic achievement (Alloway & Alloway 2010; Gathercole, Brown & Pickering 2003; Gathercole, Lamont & Alloway 2006; Gathercole et al. 2004a, 2004b). Differences in WM capacity have an immediate impact on children's cognition, their L1 acquisition and L2/FL learning (Juffs & Harrington 2011). Viewed from this perspective, a large and flexible WM is important in today's communicative FL classrooms, because young learners need to make sense of large amounts of aural and authentic data, especially during the earliest years of their schooling (Mackey et al. 2002; Sáfár & Kormos 2008).

4. The present study

4.1 The schools

The two primary schools of the study are located in Evosmos, a western part of Thessaloniki, where families are of a low to average socio-economic status. The 2nd primary school (control group) introduces EFL in Grade 3, while the 3rd Model Experimental School (experimental group) does so in Grade 1.

Since 2005 the Theoretical and Applied Linguistics Department of the School of English (Aristotle University of Thessaloniki) supervises the operation of the 3rd Model Experimental School regarding the teaching of English as a FL and is responsible for issues that pertain to curriculum design, staff selection, and teaching methodology. The program followed is intensive. In the first two years English is taught for 5 hours weekly while the focus, following Asher's (1982) *Total Physical Response* method, is on the development of children's oracy. As of 2010-11, *Content Language Integrated Learning* (CLIL) is practised from Grade 3 in various subjects (Environmental Study, Geography, etc.), increasing thus the teaching of English to 8 hours weekly. From 2010-11, the Greek Ministry of Education is running a pilot program in 800 primary schools that teach English from Grade 1, for 2 hours per week. Even so, the case of the 3rd Modern Experimental School is quite unique.

4.2 Participants

All participants were Greek monolingual speakers. The participants were located by means of a letter and a questionnaire distributed at the beginning of Grade 1 via the school principals to the students' parents. The letter explained the purpose of the research, emphasising that participation was not obligatory and that informants would be seen in hours that fall outside the school's 'core' program (i.e. Greek language, English language, Mathematics) or during the whole-day school hours (from 14:00-16:00). Due to the young age of the children, informed consent was obtained from the parents. The questionnaire was about the language used at home and the parents' L1s. In this way we excluded bilingual, trilingual students or children with previous contact with English to avoid any interference of the additional language(s). Finally, 98 children were recruited, i.e. 49 from each school. The mean ages of the experimental group were 6 years; 4 months (SD = 3 months) in Grade 1, and 7 years; 8 months (SD = 3 months) in Grade 2. The respective mean ages of the control group were 6 years; 7 months (SD = 3 months) in Grade 1, and 7 years; 7 months (SD = 3 months) in Grade 2.

4.3 Tools and skills tested

Both groups completed the same number of verbal tasks twice that tap their PSTM and CWM: in the beginning of Grade 1, before the FL intervention on the experimental group and towards the end of Grade 2, after their two-year EFL exposure. With the exception of the English vocabulary test, all other tests were administered in Greek. The English vocabulary test was taken only by the experimental group just before the end of Grade 2, because the control group had not yet had any contact with the English language as the school introduces EFL in Grade 3. Participants were tested individually in a quiet room in the school's premises. The compiled data was codified and analysed using SPSS 21.

4.3.1 PSTM measures

The capacity of PSTM was tested by the forward digit span test and two nonword repetition measures. In the forward digit span test (Wechsler 1991) participants listen carefully to a series of digits which they need to repeat in the correct forward order. Items are presented at a rate of one digit per second. Following a practice session of two trials, presentation begins with two digits in a series. Two trials are presented at each difficulty level. If a sequence is reported correctly, the length of the next is increased by one digit. The difficulty level gradually increases, reaching a maximum of nine digits in eight trials. The test stops when both trials at a level are incorrectly recalled. All correct responses were taken into account (Μασούρα et al. 2004). One point was allocated for every successful response and half a point for a partially correct one (right digits, wrong order).

Nonword repetition is a reliable measure of PSTM capacity and a good predictor of language skills in the early school years (for a review see Baddeley et al. 1998; Gathercole & Adams 1994). The two nonword tasks given to the informants were *The Children's Test of Nonword Repetition* (Gathercole & Baddeley 1996) and *The Test of Nonword Repetition for Greek-speaking children* (Μαριδάκη-Κασσωτάκη 1998). Each test consists of 40 nonwords which are auditorily presented to the informants. The words are phonologically valid sequences that are void of meaning. Additions, deletions, or replacements of a phoneme were valued as incorrect and got no point (Archibald & Gathercole 2006).

4.3.2 CWM measures

CWM was tested by the Listening span and Recall task, which is based on the listening span procedure originally developed by Daneman and Carpenter (1980) and by the backward digit span test (Wechsler 1991).

The former is a modified version of the listening span test administered by Χρυσοχόου (2006) and requires the recall of semantically and phonologically unrelated words. It has six levels of difficulty. The number of sentences in a set is incremented from level to level. Level 1 consists of six 1-sentence trials followed by a lexically unrelated word. Level 2 consists of six 2-sentence trials followed by two words, etc. In the statistical analyses that were conducted, the participants' ability to correctly recall the word (i.e. their storage capacity) was taken into account and not their semantic evaluation of the sentence(s). A point was given for every correctly recalled word. With four such cases in a set, participants were assigned six points. To be allocated a point in levels 2 to 4, they had to correctly recall a respective number of 2-4 words in each set.

Digit recall_Backwards employs the same procedure as the forward condition described in 4.3.1 in all respects, except that participants need to recall the digits in the reverse order.

Both these tasks impose a substantial WM load on children (St. Clair-Thompson 2010) because they involve the central executive and the phonological loop: they combine the concurrent storage of the lexically unrelated words or digits with processing, i.e. the semantic evaluation of the sentences or the re-sequencing of the digits.

4.3.3 The FL vocabulary test

Towards the end of Grade 2 the experimental group alone took a computerised FL vocabulary test as the control group was not yet exposed to L2 English. The test examined the group's receptive and productive skills (Efstathiadi 2013) and was based on the material covered in Grades 1 and 2. Examples of the short stories or the songs the learners were exposed to are *Winnie in Winter*, *Itsy Bitsy Spider*, etc. The thematic fields taught pertain to children's immediate environment (home, school), involve action verbs (e.g. *stand*, *sit*) found in high-frequency rote-learned chunks (e.g. *Sit down*) or formulaic expressions (e.g. *How are you? I' m fine, thanks*). The sub-tests were tapped on the same thematic fields and tested whether participants could recall and produce mostly the nouns, verbs in the present progressive, and the adjectives they had been taught (Okalidou et al. 2011). For instance, if the child was asked to identify a means of transport (e.g. car) in the receptive test, (s)he also had to name such a means (e.g. an airplane) in the productive test. A digital stopwatch was used to record the time participants needed to complete each sub-test. For every individual a scoring sheet was kept in which the following information was entered: duration of the test (minutes, seconds) and responses to each item, noting whether the response was correct, incorrect or not given. The receptive test was taken first.

5. The research questions of the study

Based on the theoretical framework presented so far and on the unique nature of the 3rd Model Experimental School, the present article wishes to:

a) examine the outcome of the intensive two-year FL exposure of the young Greek learners to L2 English. Even though the relevant literature demonstrates this to be modest, the recorded initial FL progress of the young learners will serve as a point of reference for later studies,
b) investigate the cognitive impact of EFLL on PSTM and verbal WM. The literature reports their close association with (F)LL. Due to the intensity of the L2

programme followed by the experimental school, it is expected that both constructs will be enhanced by the early FL intervention,

c) examine whether PSTM is the sole predictor of early FL vocabulary achievement. Due to the explicit effort entailed in the FLL process and the demanding nature of the school's communicative FL classroom, the expectation is that the attentional controller of WM will best explain early FL vocabulary performance.

6. Data analysis

The test means and SDs were computed separately for Grades 1 and 2 for each group. Two participants from the experimental group scored more than ±2 SDs the group mean in over 35% of the tasks in both grades so their scores were excluded from all subsequent analyses, leaving the group with 47 participants. Those who scored more than ±2SDs the group mean in some tests had their scores replaced by the test mean. Table 1 displays the descriptive statistics of Grade 2:

Skill tested	Tasks	Maximum score	Experimental group (n=47)		Control group (n=49)	
			Mean	SD	Mean	SD
Foreign language vocabulary performance	FL_Voc._Total (overall foreign language vocabulary achievement)	34	24.69	5.43		
	FL_Receptive (foreign language comprehension)	15	12.82	1.73		
	FL_Productive (foreign language production)	19	12.15	3.58		
Phonological Short-term Memory	Digit recall Forward	16	7.05	1.46	6.45	1.30
	Greek nonword repetition	40	34.99	3.59	33.22	4.05
	English nonword repetition	40	28.51	3.96	23.86	4.69
Complex Working Memory	Digit recall Backwards	14	4.31	1.10	4.08	1.06
	Listening Recall	6 points for every level attained	7.05	3.04	6.69	2.72

Table 1. Descriptive statistics (Grade 2)

6.1 The English vocabulary test

To evaluate the overall performance of the experimental group, no exclusionary criteria were applied. Thus, all 49 scores were entered in the statistical analyses. To be able to chart individual performance in the two skills, we recorded the time each participant needed to complete each sub-test and their responses. Concerning the marking of the responses, the scores were distributed along three categories: a) the first captures those that were below the median quartile (≥7 for the receptive test and ≥9 for the productive), b) the second captures the range of scores between the median and lower limit of the upper quartile, hereafter referred as M-Q3 range (receptive: 8-11; productive: 10-14), while c) the third category includes the scores that ranged above the upper quartile (receptive: 12-15; productive: 15-19).

6.1.1 Comprehension in the English language

Figure 1 illustrates the performance of the informants, with respect to speed and accuracy. Note that each cycle represents one case.

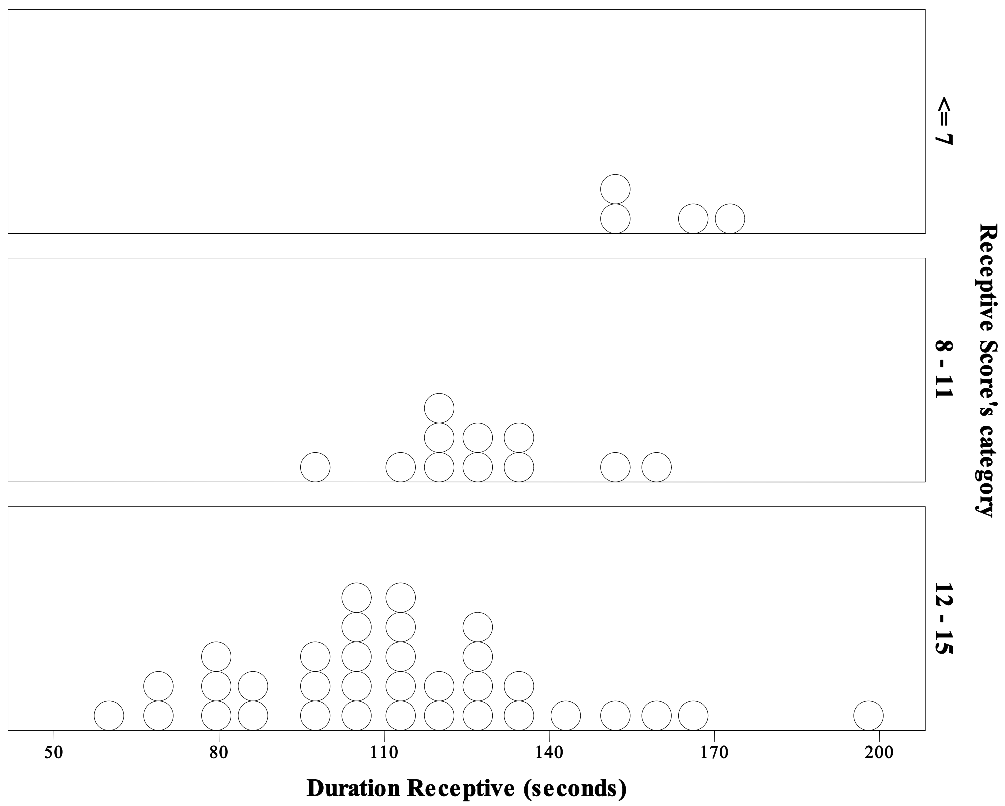

Figure 1. The informants' performance in the receptive test

Of the 49 informants, 4 students (8.2%) scored below the median quartile, 11 (22.4%) scored in the M-Q3 range, and 34 (69.4%) scored above the upper quartile.

6.1.2 Production in the English language

Figure 2 illustrates the group's performance with respect to speed and accuracy:

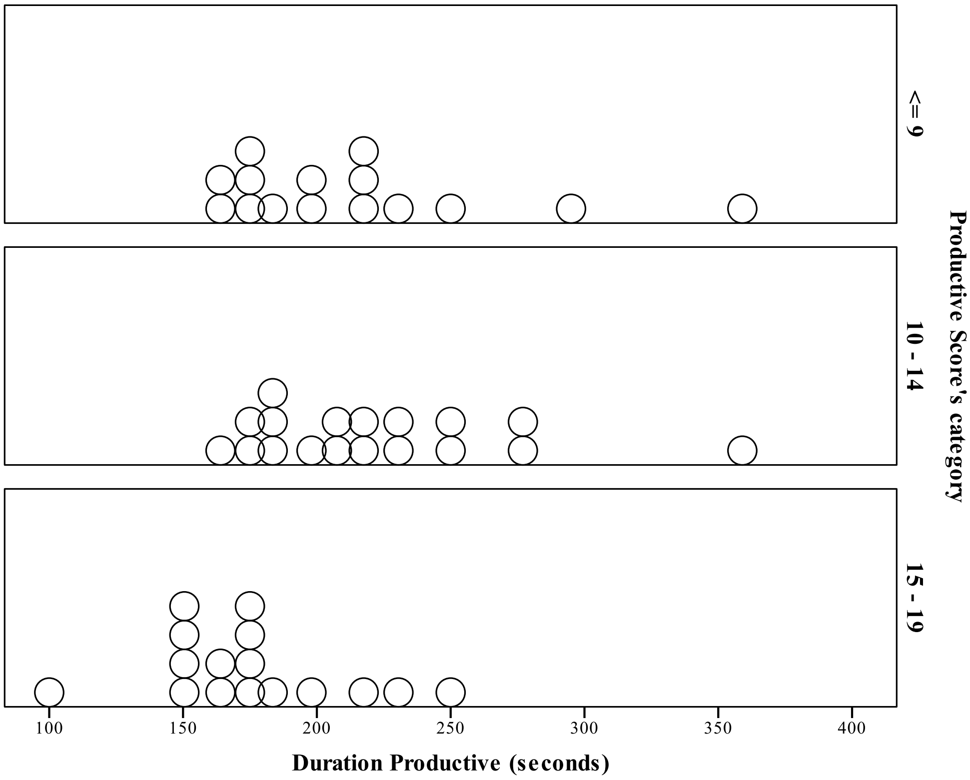

Figure 2. The informants' performance in the productive test

Figure 2 shows that 15 students (30.6%) scored below the median quartile, 18 (36.7%) scored in the M-Q3 range, and 16 (32.7%) scored above the upper quartile. Table 2 below summarises these findings and gives a detailed picture of the group's combined performance:

			Productive test			Total
			≥9	10-14	15-19	
Receptive test	≥7	Count % of Total	**4**	0	0	4
			8.2%	.0%	.0%	8.2%
	8-11		9	**2**	0	11
			18.4%	4.1%	.0%	22.4%
	12-15		2	16	**16**	34
			4.1%	32.7%	32.7%	69.4%
Total			15	18	16	**49**
			30.6%	36.7%	32.7%	100.0%

Table 2. The informants' combined performance

Overall, production was more difficult than comprehension in the FL. Of the 11 students that scored in the M-Q3 range in the receptive test, 9 students scored below the median quartile (≥9) and only 2 scored equally well in the productive test. Of the 34 students that scored above the upper quartile in the receptive test, 2 students scored below the median quartile, 16 scored in the M-Q3 range, and 16 scored equally high in the productive test. This difficulty was also reflected in their finishing times. While students needed 100 to 363 seconds to finish the productive test, they needed almost half this much time for the receptive one (range: 60-198 seconds).

The diagonal in bold (Table 2) marks the cases that exhibited no difference in performance, namely the number of participants who performed equally poor, average, or good in the two tests: 4 students scored below the median quartile, 2 scored in the M-Q3 range, while 16 scored above the upper quartile in both tests. In order to track whether the group's performance was any different during FL comprehension and production, we conducted a chi-square analysis: we compared the student cases that did not manage to go to a higher quartile (the upper part of the triangle) in the productive test with those that scored significantly better in the receptive one (the lower part of the triangle). A closer look at Table 2 shows, for instance, that of the 4 students who scored below the median quartile (≥7) in the receptive test, none managed to score higher than the respective median quartile of the productive test (≥9). On the contrary, of the 15 students who scored below the median quartile (≥9) in the productive test, 9 managed to score in the respective M-Q3 range of the receptive test (8-11) while another 2 students scored above this test's upper quartile (12-15). The chi-square analysis yielded a significant difference in the group's combined performance: $\chi^2 = 33.051$, $df = 4$, $p < .001$.

6.1.3 Stepwise regressions

To examine whether CWM plays a predictive role in early L2 vocabulary performance, we conducted various stepwise regressions in Grade 2. English vocabulary achievement is represented by data in the two L2 skills (comprehension, production) and an aggregate score. We examined whether overall L2 vocabulary performance or separately comprehension and production can be predicted by PSTM and/or CWM.

When the aggregate English vocabulary score was the dependent variable, the Greek nonword repetition task explained 14% of the variance in its scores, $F(1,45) = 8.510$; $p < .01$, while Listening Recall accounted for 11.3% of the variance in its scores, $F(1,45) = 6.835$; $p < .05$. When L2 comprehension was the dependent variable, Listening Recall accounted for 17.7% of the variance in its scores, $F(1,45) = 10.895$; $p < .01$, whereas the Greek nonword repetition task explained a respective 16%, $F(1,45) = 9.788$; $p < .01$. When L2 production was the dependent variable, Listening Recall accounted for 15.8% of the variance in its scores, $F(1,45) = 9.615$; $p < .01$, while the Greek nonword repetition task explained a respective 15%, $F(1,45) = 9.086$; $p < .01$.

6.2 Between- and within-group analyses

We first tested the null hypothesis to examine whether the two groups displayed any marked differences before the FL intervention on the experimental group, i.e. at the beginning of Grade 1. This was viewed necessary as we had to know the starting point of the experimental group before their FL schooling to then be able to compare it with the group's performance at the end of the two-year FL intervention. To this end, we conducted independent samples *t*-tests for Grades 1 and 2, the results of which are displayed in Tables 3 and 4 respectively:

Measures	**Group**	**Mean**	***t*-test**	**SD**
Digit recall Forward	experimental	6.13	$p > .1$	1.64
	control	5.70		1.00
Greek nonword repetition task	experimental	34.04	$p = .000$	3.61
	control	30.14		5.44
English nonword repetition task	experimental	25.78	$p = .007$	4.96
	control	22.56		6.36
Digit recall Backwards	experimental	3.07	$p = .032$	0.81
	control	3.45		0.89
Listening Recall	experimental	5.67	$p > .1$	2.72
	control	4.73		2.32

Table 3. Independent samples t-tests, Grade 1

Measures	Group	Mean	*t*-test	SD
Digit recall Forward	experimental	7.05	$p = .037$	1.46
	control	6.45		1.30
Greek nonword repetition task	experimental	34.99	$p = .026$	3.59
	control	33.22		4.05
English nonword repetition task	experimental	28.51	$p = .000$	3.96
	control	23.86		4.69
Digit recall Backwards	experimental	4.31	$p > .1$	1.10
	control	4.08		1.06
Listening Recall	experimental	7.05	$p > .1$	3.04
	control	6.69		2.72

Table 4. Independent samples t-tests, Grade 2

As it becomes clear, the experimental group outperformed the control in the tasks that assess PSTM. The finding was considered accidental as all participants were local residents of the same neighbourhood, shared the same socio-economic background, while the experimental school applies no special exclusionary criteria upon first grade enrollment. In Grade 2, the experimental group maintained its initial advantage in the Greek nonword repetition task, strengthened its advantage in the English nonword repetition task, and gained an additional one in Digit recall Forward. Regarding the CWM tasks, no difference emerged between the two groups (in both grades) for Listening Recall. Finally, in Grade 2 the control group lost its initial advantage in Digit recall Backwards, the only test in which it had outperformed the experimental group in Grade 1.

In order to have a more detailed picture of the combined performance of the two groups in each of the tests across the two grades, we then performed two-way ANOVAs as they are more robust in nature. Overall, the experimental group outperformed the control in both grades. More specifically, in Grade 2 the experimental group outscored the control in Digit recall Forward (: F(1,188 = 17.865, p = .000, η_p^2 = .087), the Greek nonword repetition task (: F(1,188) = 10.804, p = .001, η_p^2 = .054), the English nonword repetition task (: F(1,188) = 7.565, p = .007, η_p^2 = .039), and, interestingly, Digit recall Backwards (: F(1,188) = 4.634, p = .033, η_p^2 = .024). This last finding was the most prominent difference between the two groups because, as already mentioned, this was the only test in which the control group had outscored the experimental in Grade 1 ($t(94) = -2.176$, $p < .05$). The paired samples *t*-tests in the experimental data (before and after the FL intervention) confirmed the magnitude of the difference attested for the experimental group in Grade 2: $t(46) = -8.603$; $p < .001$, $d = -1.25$.

To conclude, the results in Tables 3 and 4 suggest that both the PSTM and CWM of the experimental group were positively influenced by the early and intensive FL intervention.

7. Discussion of the findings

The aim of the research was threefold. The first goal was to record the L2 vocabulary performance of the young Greek learners who had followed an intensive FL programme at school for two years (5 hours per week, 360 hours in total). The second aim was to examine whether EFLL had a boosting effect on their PSTM and CWM, while the third was to explore whether CWM was a stronger predictor than PSTM of early FL vocabulary achievement.

Regarding the first goal, the findings suggest that the informants faced more difficulty with L2 production than L2 comprehension, which was also reflected in the finishing times of the two tests. This is indicative of the different nature of the two processes (Harley 2001) and the different complex psycholinguistic mechanisms engaged in each (for a detailed discussion see Izumi 2003), that tend to become even more prominent with novice L2 learners. What should be kept in mind is that at the time of testing the experimental group was still at a very early stage of FLL, and consequently possessed only limited FL resources and learning strategies (Cole & Cole 2001). Clearly, the processes of noticing or pattern identification (see Skehan's 2002 model of SLA processing) which immediately affect one's retrieval ability were still under development in these young learners who had only been exposed to English for two years. Evidently, they need more time and ample opportunities to get exposed to the FL, repeat the foreign vocabulary (Webb 2007) before they ever manage a deeper FL processing and a more stable representation of the L2 material in their LTM, that would firmly associate form with meaning (Baddeley et al. 1998; Izumi 2003; Service 1992) and would lead to a more automated L2 processing (Andersson 2010). The findings support previous literature on meaning-focused interaction which suggests that spontaneous production emerges very slowly in the first two years (Lundberg & Lindgren 2008, cited in Nikolov & Mihaljevic Djigunovic 2011) and substantial time is needed before creative and fluent speech develops (Blondin et al. 1998). What should also be taken into consideration is that at the end of Grade 2 the experimental group was not yet literate in English. Early FL literacy (from the age of 7/8), however, has been reported to accelerate overall FL performance (Johnstone 2009). Therefore, the results primarily reflect the group's FL vocabulary performance that is still developing.

The findings are in line with previous studies which demonstrate that EFLL is a time-consuming process (Larson-Hall 2008), with modest linguistic outcomes in the short-term (Nikolov 2009) but valuable gains in the long-run (Muñoz 2006, 2010). Even so, an earlier start still offers a prolonged period of FL exposure to the young learners, during which time their cognitive growth can be positively influenced, even enhanced, while it is still developing (Efstathiadi 2014).

As regards this study's second aim that pertains to the cognitive impact of EFLL, the results demonstrate that the cognitive constructs investigated, namely PSTM and CWM, were both boosted by the early introduction of the FL. This is truly important as PSTM has been viewed to be the foundation for FLL (Cheung 1996; Μασούρα et al. 2004) that supports memory performance and facilitates the ease with which learners acquire new lexical material (Gathercole & Adams 1994; Masoura & Gathercole 1999). The attentional controller of WM was also enhanced, which can be explained by the increasing demands of the communicative L2 classroom of the experimental school. The authentic FL material that had been presented to the learners aurally, posed high attentional demands on them (Kormos & Sáfár 2008) because they had to employ the best of their attentional skills to notice (Sawyer & Ranta 2001) and then encode the new pieces of information. Gathercole and Alloway (2008) support the key role WM plays in learning within an instructed context and consider this to be 'a bottleneck for learning' (ibid.: 24): whatever input enters WM may potentially become part of LTM. In this sense, the findings are important, as an efficiently operating WM can critically affect knowledge acquisition over the school years.

As far as the study's third goal is concerned, the role of CWM in EFLL was also demonstrated. Regarding the overall FL vocabulary performance, the regressions suggest that PSTM was a slightly stronger predictor than CWM. Nevertheless, in a finer analysis of the data, when comprehension and production were examined separately, CWM better explained early FL vocabulary performance. Thus, to perform well in the FL vocabulary test, the informants relied on the phonological loop to temporarily store the phonological representations of the new FL words. More important, however, is the fact that they depended heavily on the central executive of WM for the coordination and allocation of their cognitive resources during the execution of complex processes that take place during the L2 processing (Izumi 2003).

The findings are aligned with previous studies on the link between PSTM and EFLL (Alexiou 2005; Cheung 1996) while they also establish a close relationship between the central executive and early FL vocabulary achievement. The results support Kormos and Sáfár's view (2008) on the different roles PSTM and CWM serve in instructed FLL: with L2 beginners, CWM seems to play a more decisive role than PSTM as it stimulates the learners' explicit learning mechanisms. With more advanced FL learners, however, the capacity of the loop facilitates the further expansion of their lexical repertoire.

Our results support the implementation of early and intensive FL programmes as they suggest that EFLL can enhance young learners' WM. Assuming that the limited *M*-capacity of Pascual-Leone (1970) remains stable in one's lifetime, the findings are important in that EFLL can help WM operate in an efficient and automatic manner much earlier than previously suggested. This, in turn, is expected to set free the attentional resources much earlier that will then be devoted to a deeper semantic and syntactic processing of the L2 input (Case, Kurland & Goldberg 1982; Hummel & French 2010), with direct positive consequences for the FLL process.

8. Conclusion

The great majority of the EFLL research conducted so far has primarily focused on the linguistic and affective impact of EFLL. This article, on the one hand, has shown that a two-year intensive FL intervention is a rather short period to assess the FL vocabulary performance of the young learners and clearly more time, input and contact with the FL is needed before any valuable gains begin to emerge. On the other hand, however, it has demonstrated a boosting effect of EFLL on the cognitive constructs of PSTM and CWM, which were both enhanced by the early and intensive FL intervention. In addition, the reported findings have established an interesting and powerful relation between the central executive of WM and early FL vocabulary performance.

In conclusion, this article may lend further support to the issue of bi-directionality and the interaction found between the L1 and the FL (Mihaljevic Djigunovic 2010). If EFLL facilitates a more effective and flexible cognitive functioning and enhances the cognitive skills of young children (Efstathiadi 2014), then one may speculate that this will also trigger in the following years a 'domino effect' on other school subjects and an overall better learner scholastic achievement. Clearly, this constitutes the direction of our future research agenda.

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