Executive attention in proactive interference: Evidence from a Greek experimental school implementing CLIL

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Abstract
The study examines the performance of non-bilingual young learners in a verbal task involving executive attention. The forty-eight participants were Greek monolingual students, attending Grade 6 in a partial immersion primary school that implements Content and Language Integrated Learning (CLIL). They were divided into two groups according to degree of CLIL exposure, but all followed the same intensive EFL programme. The experimental group (CLIL+) had a four-year CLIL exposure while the control group (CLIL-) had a two-year CLIL experience. The study investigates whether apart from early bilingualism (Bialystok & Feng 2009) FL immersion can also yield cognitive gains in executive attention. The findings suggest that the experimental group was better able to allocate attention and control inhibition, compared to the other group.

Keywords: CLIL, proactive interference, executive attention, young learners

1 Introduction
What underlies our ability as humans to function daily and successfully perform all kinds of higher-order cognitive tasks is a domain-free executive attention system responsible for the proper operation of Working Memory (WM) (Kane & Engle 2000). Following the multidimensional WM model of Baddeley & Hitch (1974), Kane & Engle (2000) hold that the central executive or executive attention, regulates the contents of WM by controlling attention, allocating resources, keeping temporarily
active in memory only what’s currently relevant while simultaneously blocking out all other information.

Engle (2012: 20) calls the “ability to control attention to maintain information in an active, quickly retrievable state” WM capacity, and holds that greater WM capacity presupposes fully operative attentional resources that make possible the suppression of distraction and the blockage of inappropriate responses. On these grounds, he argues, WM capacity is not so much about having a spacious memory store but about the ability to properly allocate attention and keep information active or suppressed, depending on contextual demands.

1.1 The Proactive Interference task
Such a challenge on memory is posed by the Proactive Interference (PI) paradigm, which is a measure of executive function (Bialystok & Feng 2011). The task involves executive control (i.e. the ability to monitor and control attention to the words in each list) and the update of WM, blocking the build-up of interference in this verbal task by retrieving only the current list of words (Engle 2012; Kane & Engle 2000). PI occurs when retrieval of the material recently presented is compromised by prior exposure to similar items. The subsequent presentation of information (with the goal to learn this for immediate recall) that belongs to the same semantic category, makes it difficult to distinguish which item was presented most recently; consequently, memory declines and the rate of the accurately recalled words on the last presented list decreases. Such a decrease reflects the buildup of PI while release from PI occurs when the stimulus category changes on a subsequent list and recall returns to original levels of List 1.

If one manages to deal with such PI effects on memory, then most of the information he/she keeps in Long-term memory and uses daily will be sufficiently and quickly retrieved from this memory store, allowing the successful performance of other complex cognitive functions taking place in WM. In case inhibition proves inefficient and attentional processes fail to regulate the flow of only the relevant from “thought and perception” and to delete the irrelevant from consciousness (Hasher, Zacks & May 1999, as cited in Hasher et al. 2002: 201), then the system gets overloaded and the proper processing of new information and eventual knowledge acquisition is disrupted (Alloway 2006; Dempster 1992; Gathercole & Alloway 2008; St. Clair-Thompson & Gathercole 2006). Given the limited capacity of WM
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(Baddeley 2003) and its close association to learning\(^1\), it becomes evident that a stronger executive control system is particularly important in the school context as it facilitates the acquisition of skills and knowledge in general.

1.2 Performance in the PI task and the rationale for the study

Much variation has been attested in people’s ability to maintain and inhibit information in the face of distraction (Kane & Engle 2000: 21). The PI effect has been found in children (Dempster 1992; Kail 2002) and adults (Hasher et al. 2002), with younger adults displaying a more efficient WM capacity than older ones (Hasher, Zacks & May 1999, as cited in Hasher et al. 2002). Research with monolingual children indicates that the buildup of PI decreases between the ages of 4 and 13, as children develop better cognitive control (Kail 2002).

Bialystok & Feng (2009, 2011) also compared the performance of monolingual and bilingual children in this task and reported that the ability of the latter group to process, monitor and recall lists of words was not compromised as perhaps one would expect, since bilinguals usually score poorer than monolingual peers in vocabulary tasks. On the contrary, bilingual children experienced less interference from the competing words and showed less buildup of PI than their monolingual counterparts.

On these grounds, the authors concluded that the advantage of bilinguals in executive control can extend to a task based on verbal processing, helping them in this way to improve their performance in this domain too. So, studies thus far (for a review and discussion see Bialystok 2011) have linked the bilingual experience with an enhanced executive control mechanism. Bialystok (ibid) explains this happens because bilinguals heavily rely on their attentional resources to resolve the conflict created by the concurrent activation of their two languages.

The study reported here further examines whether such a prospect can also be viable in a non-bilingual population when this is deeply immersed to a FL. The participants of the study had been attending a partial immersion school for six years and had a very close contact with the FL daily. The study participants were first seen at the end of Grades 1 and 2 of primary school, i.e. before L2 literacy was in place. At that time, the goal was to investigate the cognitive impact of their early and intensive exposure to L2 English from Grade 1 (Efstathiadi 2014). The experimental data were

\(^1\)WM has been viewed as a “learning device” (Baddeley 2010) and a gateway to LTM (Wen & Skehan 2011).
compared against others from a mainstream school (control group), introducing L2 English in Grade 3. The findings suggested the experimental group’s better performance in FL aptitude (associative memory and inductive reasoning ability) while FL aptitude, Phonological Short-term Memory and Complex WM (i.e. executive attention) were all implicated to a different degree and predicted the group’s performance in both L1 and L2 vocabulary tests (Efstathiadi 2014, 2016). In the following four years, learners became fully literate in English while the experimental group (CLIL+) was introduced to CLIL much earlier than the control one (CLIL-) (see section 2 below). Therefore, the study wishes to examine whether partial FL immersion, realised via two CLIL programmes of varied duration and intensity, can yield a different picture regarding cognitive gains in the two groups. As is explained in what follows, the school implements CLIL in an effort to further intensify the existing EFL programme offered.

1.3 Content and Language Integrated Learning (CLIL)

Since the 1990s, CLIL immersion programmes have become more and more commonplace in Canada, the Basque country, and Europe (Dalton-Puffer 2008; Eurydice report 2017). CLIL classrooms provide a context for naturalistic FL learning as most learning takes place informally and incidentally and not through explicit language instruction (Mattheoudakis et al. 2014). Students receive additional FL exposure through the balanced integration of the content of another school subject (e.g. History, Geography) and the FL in one school hour. In this sense, these programmes constitute a form of bilingual education and as such they are expected to carry at least some of the advantages of bilingual education (Cummins 1984). The CLIL methodology is considered an effective and alternative way of further improving students’ FL skills (Lasagabaster 2008), with some skills (receptive, vocabulary acquisition) being more developed than others (productive, writing) (Dalton-Puffer 2008). Also, studies on CLIL report students’ heightened motivation, increased confidence and risk-taking in using the FL in creative, meaningful and purposeful ways (Coyle et al. 2010; Dalton-Puffer 2008; Dalton-Puffer & Smit 2007; Lasagabaster & Sierra 2009).
2 Method

2.1 Participants

The study included forty-eight Greek-speaking children. At the time of testing they were in Grade 6 of the 3rd Experimental School in Thessaloniki, which has been offering CLIL classes from the early grades of primary school since 2010-11 (Mattheoudakis et al. 2014). The school introduces L2 English with five hours/week in the 1\textsuperscript{st} and 2\textsuperscript{nd} grades; these increase to eight hours/week in the following grades. On top of the English classes all learners received, CLIL was systematically introduced to them from the 3rd or the 5th grade, depending on the CLIL programme they followed, with respect to the number of years of CLIL exposure and the total number of hours allocated to the teaching of other school subjects via English.

Thus, the participants were divided into two groups, according to degree of CLIL exposure. The group with the least exposure (CLIL-, $M_{age}$ 11.5 years, $SD = 0.3$) consisted of thirty-one children (eleven boys, twenty girls) who were moderately introduced to CLIL in Grade 5 (Arts, 1 hour/week) and Grade 6 (Geography or Computers, 2 hours/week). The group that was overall more exposed to CLIL (CLIL+ group, $M_{age}$ 11.6 years, $SD = 0.3$) consisted of seventeen children (eight boys, nine girls) who had attended CLIL classes for 2 hours/week from Grade 3 to Grade 5. They had been taught History through English in Grade 3, Environmental Studies in Grade 4, Religious Education in Grade 5, and Geography as well as Religious Education in Grade 6 (4 hours/week). At the beginning of Grade 4 they were all streamed according to L2 proficiency: level 1 were the advanced learners, level 2 the intermediate ones and level 3 the low level learners. Both groups included learners of all three L2 proficiency levels. Of the seventeen children of the CLIL+ group, eight belonged to level 1, four to level 2 and five to level 3. Similarly, of the thirty-one children of the CLIL- group, fifteen belonged to level 1, seven to level 2 and nine to level 3. All the children lived in the same neighbourhood and were matched for SES (parental education). Due to their young age, parental consent was obtained for the children’s participation in the study.
2.2 Material
In order to assess performance in WM capacity (Engle 2012) or executive attention we used the Greek adaptation\(^2\) of the PI task, initially developed by Kane & Engle (2000).

2.3 Procedure
The children were tested individually in a quiet room in the school premises. The test was administered in Greek and lasted approximately ten minutes. The children were given stickers, pencils/pens upon completion for their participation.

The PI task was programmed in E-prime and was presented by the experimenter on a Toshiba laptop computer. The children were presented with four lists of seven words each. The high frequency stimuli belonged to two categories: the words in the first three lists belonged to the semantic category of fruits while those of the last list were related to sports. All words were presented both visually and orally at a rate of one word every 2 s. Upon completion, each list was immediately followed by a filler task that lasted 10 seconds. A two-digit randomly chosen number was presented on the screen and participants were instructed to count forward from that number (for 10 seconds). This filler task means to increase the cognitive load and block the rehearsal of the seven words of the list. Then participants were given 10 seconds to recall as many words they could remember, in any order, from the ones just presented. The same procedure was followed for all four lists. The number of words recalled and the number of intrusions from previous lists were recorded on the children’s individual scoring sheets.

Two are the indices of PI buildup typically measured across the first three word lists: a) a decline in recall in Lists 2 and 3 as compared to List 1 and b) heightened intrusion rates; when previously presented words are not successfully deleted from WM, it is highly likely they will emerge during the following two trials, because of their semantic relevance with the subsequent words. Improvement in recall is an index of release from PI and occurs when the category changes in List 4.

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\(^2\) The test was adapted into Greek as part of the THALES research project “Bilingual acquisition and bilingual education: The development of linguistic and cognitive abilities in different types of bilingualism”. Acknowledgments to the project’s co-ordinator, I. M. Tsimpli, for allowing access to the experiment.
2.4 The research questions
To investigate the link (if any) between degree of intensity of the FL programme and a cognitive benefit in executive attention, the following questions were formulated:

a) Will the experimental group manage to combat interference and recall more words in the first three lists and also throughout the task than the control group?

b) Will the experimental group allow less intrusions of competing words from previous lists than the control group?

Regarding the first question, both groups are expected to perform similarly, following the pattern that the relevant literature has demonstrated so far: word retrieval will be gradually compromised from List 1 to List 3, due to the confusion caused by the semantic proximity of words, to return to original levels in List 4 when this ceases to exist. As for the second question, a positive answer would suggest the experimental group’s heightened ability to allocate attention and control inhibition, indicating thus that deeper immersion to the FL may enhance one’s executive control system. Quite the contrary, a negative answer would suggest that both groups perform the same regarding intrusion rates, failing to maintain the relevant when distracted. This would indicate that degree of immersion to the FL leaves one’s WM capacity (Engle 2012) quite unaffected.

3 Results

Table 1 reports the mean number of words correctly recalled in each list by the two groups.

<table>
<thead>
<tr>
<th>List</th>
<th>CLIL-</th>
<th>CLIL+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.84 (0.19)</td>
<td>5.00 (0.17)</td>
</tr>
<tr>
<td>2</td>
<td>2.71 (0.24)</td>
<td>3.59 (0.31)</td>
</tr>
<tr>
<td>3</td>
<td>2.42 (0.21)</td>
<td>3.06 (0.32)</td>
</tr>
<tr>
<td>4</td>
<td>5.52 (0.14)</td>
<td>5.88 (0.17)</td>
</tr>
</tbody>
</table>

*Table 1. Mean number of words recalled across lists and standard error*
3.1 Performance of both groups in word recall

The performance of the two groups across the lists is depicted in Figure 1.

The results conform to the standard pattern for this task (Bialystok & Feng 2009) as recall declines in the first three lists, reflecting the buildup of PI, to eventually return to original levels in the fourth list. The univariate ANOVAs performed with List (1 to 4) as the within-subjects factor and CLIL exposure (CLIL+, CLIL-) as the between-subjects factor showed a main effect of list, $F(3,184) = 80.3, p < .001$ and an effect of CLIL exposure, $F(1,184) = 10.53, p = .001$. Post-hoc analyses using Tukey HSD indicated an identical pattern for both groups: a significant decline in the recall of words from List 1 to List 2 ($p < .001$), an insignificant decline from List 2 to List 3 ($p = .30$) and a full recovery in List 4 ($p < .001$), surpassing original levels of List 1 ($p = .003$). In other words, both groups improved performance in List 4, with the shift in semantic category from fruits to sports.

Although there was no interaction of List and CLIL exposure, the change in performance across lists varied for each group; therefore, separate analyses were conducted to detect subtler differences previously suggested in the literature (Bialystok & Feng 2009). The only additional difference that emerged was that the experimental group’s last effort in word recall was significantly better than its first ($p$
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Performance was also considered for each group with regard to difference in recall in Lists 2 and 3, relative to the baseline established in List 1 (Bialystok & Feng 2009 call this ‘proportional PI effect’). The experimental group exhibited a marginally significant smaller decline from List 2 to List 3 $F_{(1,138)} = 3.70, \ p = .057$. (See Appendix I for a graphic illustration).

3.2 Intrusion errors

Heightened intrusion rates also indicate the buildup of PI. The following results concern recall errors made in Lists 2 and 3 that indicate the intrusions from words belonging to the same category that had appeared in a previous list. The ability to prevent these intrusions reflects executive control. The control group committed more intrusions in total in Lists 2 and 3 ($M = .61, SD = .64$) than the experimental group ($M = .26, SD = .51$). A univariate ANOVA showed an overall effect of CLIL exposure on Lists 2 and 3, $F_{(1,92)} = 7.65, \ p = .007$, while one-way ANOVAs showed marginal differences for Lists 2 and 3 in the CLIL+ group: List 2, $F_{(1,46)} = 3.91, \ p = .054$; List 3, $F_{(1,46)} = 3.85, \ p = .056$. This is illustrated in Figure 2.

![Figure 2. Means of intrusion rates in Lists 2 and 3](image)

3.3 Release from PI

To assess the release effect, we compared recall in Lists 3 and 4, using a univariate ANOVA with List (3, 4) as the within-subjects factor and CLIL exposure (CLIL+, CLIL-) as the between-subjects factor. Both groups yielded significantly better recall rates in List 4 than List 3 ($M_{list3} = 2.65, SD = 1.12; M_{list4} = 5.65, SD = .76$); $F_{(1,92)} =$
221.28, \( p < .001 \) , while a CLIL exposure effect also emerged from List 3 to List 4 \( F_{(1,92)} = 6.39, \ p < .05 \).

4 Discussion

The results provide a view of how two groups of young Greek learners of L2 English, who had been following an intensive EFL programme but had been differently exposed to CLIL, performed in a verbal paradigm that involves executive control.

Previous research demonstrated that the ability to perform controlled processing and inhibit the distraction of the no longer relevant and so better allocate attention, are some of the advantages bilingual children enjoy when compared to monolingual peers (Bialystok 2011; Bialystok & Feng 2009; Martin-Rhee & Bialystok 2008).

This study further examined the possibility of such a cognitive gain emerging in populations who are not bilingual but had been educated in a bilingual context for six years, as they were attending an experimental primary school for the teaching of English, which follows an intensive EFL programme. Previous studies (Efstathiadi 2014, 2016) suggested the involvement of executive control in the L1 and L2 vocabulary achievement in the early days of their FL schooling, when participants were not yet literate in L2 English. The aim of the present study is to see whether difference in degree of CLIL exposure will be ‘translated’ as difference in degree of cognitive gain. To this end, we examine the validity of the hypothesis holding that the experimental group (introduced to CLIL in Grade 3) will exhibit better executive control than the control group (introduced to CLIL in Grade 5), as a result of the former group’s deeper immersion into L2 English.

The first research question examines whether the experimental group will yield better word recall rates across the first three lists and in the final one, indicating thus an increased ability to update WM and to resist distraction. As is already suggested by the literature (Bialystok & Feng 2011; Engle 2012; Kane & Engle 2000), the expectation was that both groups would perform similarly and would not escape the inherent traps posed by the task: the filler task causes significant distraction and impairs word recall, as it blocks sub-vocal rehearsal and the consequent update of

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3 CLIL is one of the alternative methods (e.g. Total Physical Response, Asher & Price 1982; Multisensory Approach, Birsh 2005) the school implements in the teaching of English.
WM, while the semantic proximity of the words in the first three lists makes the task of retrieval even more difficult.

The pattern of the findings indicates that the hypothesis was partially confirmed. Recall data from both groups draw the usual pattern for the paradigm (Bialystok & Feng 2009) as there was a steady impairment of performance in the first three lists (PI buildup) and a significant improvement in word recall from List 3 to List 4 (PI release), when the semantic category changed. Regarding overall performance in the task, the experimental group displayed a more balanced picture throughout. They displayed significantly better rates in Lists 2 and 3 than the control group, while they also marked significant improvement when their performance in List 4 was compared against that of List 1.

The ability to prevent word intrusions reflects an enhanced executive control system and strong inhibition. The second research question examines whether the experimental group will better control attention and delete the irrelevant from WM, keeping currently active only the target words of each list (Hasher, Zacks & May 1999, as cited in Hasher et al. 2002). A close look at the intrusion errors, suggests that interference was more evident in the control data, as they suffered greater PI effect in Lists 2 and 3. As regards PI release, the comparison of the words recalled in Lists 3 and 4 suggests that while both groups recorded better recall rates in List 4, the experimental group still performed better than the control one at that final stage of the task.

To conclude, even though both groups followed the same pattern for the paradigm, the group that was overall more exposed to English (via the more intensive CLIL programme followed) displayed a more balanced performance throughout the task. In the context of this verbal memory task they displayed an increased ability to distinguish between target and irrelevant items and were better able to relieve the temporary and limited memory system from the excess load of the non-target words. Quite the contrary, the control group displayed reduced inhibition and thus reported all the contents of their WM, regardless of their status as current or previous items to be recalled. Taking into account the view of Baddeley & Hitch (1974) on the limited nature of the WM system, the decreased ability of the latter group to update their WM may consume valuable cognitive resources. The findings are significant, as WM and inhibition are the two executive functions that depend upon each other’s proper operation to jointly regulate the cognitive control of all human behaviour (Miyake et
al. 2000). Reduced ability in executive function and attention often co-occurs with short attention spans, high levels of distractibility, and generally problems in monitoring work (Gathercole et al. 2008) which all disrupt and/or delay the incremental process of learning and the acquisition of complex skills and, finally, compromise school achievement (Alloway 2006).

5 Concluding remarks

Summing up, the findings, which are more suggestive than conclusive⁴, demonstrate that the experimental group that enjoyed a deeper immersion to the FL, displayed a greater WM capacity (Engle 2012) than the control group. The differences found may not be as sharp as the ones that emerged between early bilinguals and their monolingual counterparts (Bialystok & Feng 2009), but this in a sense is expected as the participants of this study are all monolingual L2 learners. Still, the findings are important as they provide evidence of significant improvement in executive attention in a non-bilingual population that is schooled in a partial immersion school that favours the intensive, continual use of L2 English via the additional CLIL instruction offered.

Greece is one of the very few countries in Europe where CLIL has not been implemented yet. The experimental school for the teaching of English where this study was conducted, has been running CLIL classes since 2010 and thus constitutes the first official attempt of the Greek state to introduce CLIL in education. The findings are important as they suggest that the experimental group enjoyed a cognitive advantage that is usually found in early bilinguals (Bialystok 2011) which, in the long-run, may improve general school performance. In this sense, the findings of the study have a great pedagogic value as they may be used in support of the intensification of FL programmes in state schools, via the further expansion of CLIL provision in all of the Greek territory.

⁴ The number of the participants, even though small, reflects a definite trend. To make this more robust, similar research should be attempted in the future with larger populations.
References


Appendix

The score representing proportional change across lists was calculated by dividing the difference between the number of words recalled in List 1 and Lists 2, 3 or 4 each time, by the number of words recalled in List 1. Proportional changes in recall for Lists 2 and 3 are depicted in Figure 3. For example, what the figure illustrates is that the control group’s performance declined by 44% from List 1 to List 2, to further decline in List 3. Univariate ANOVAs with List (Lists 1-2, Lists 1-3) as the within-subjects factor and CLIL exposure (CLIL+, CLIL-) as the between-subjects factor, showed that the difference between Lists was significant: $F_{(2,138)} = 72.31, \ p < .001$.

*Figure 3. Proportional PI effect in Lists 2 and 3*