Neurophysiological maturity and the use of ICT in teaching English

**Miriam Romero López [1], Montserrat López Fernández[1]
and María Carmen Pichardo Martínez[1]**

[1] Department of Evolutionary Psychology and Education,
University of Granada

Spain

Correspondance: Miriam Romero López. Facultad de Ciencias de la Educación. Campus Universitario de Cartuja s/n, 18071. Granada (España). E-mail: miriam@ugr.es

Miriam Romero López, Montserrat López Fernández & Maria Carmen Pichardo Martínez

Abstract

Introduction: The huge impact of technology in the last few decades, and the ample development of information and communication technologies (ICT) has established them as an essential characteristic of today's society. This vertiginous advance, and the quantity and diversity of changes in knowledge that are being generated, are inducing important innovations and transformations in the school environment and its curriculum. The irruption of ICT in the educational sphere entails an increase in motivation and an interest in the learning processes of each student. Likewise, greater autonomy and competence have been fostered within this society in state of continual transformation. On the other hand, the quantity of time that each student dedicates to using certain technologies (mobile phones, internet, social media and videogames) outside of the school environment, and the variety of digital and audiovisual resources that are being developed, leads to a need to consider their influence on some of the basic psychological processes used in learning, and their relevance to teaching practice. It has been demonstrated that the use of ICT influences skills such as attention, perception and memory. For this reason, this investigation aims to: a) analyze the influence of ICT on the learning of second languages – concretely, on learning English; b) test whether there is a relation between neurophysiological maturity and learning second languages; c) discover the role played by attention in learning second languages; and d) to investigate whether learning second languages through ICT influences students' motivation.

Method: 70 students (35 girls and 35 boys) aged between 10 and 11 years old participated in this study. The students are in their fifth year of primary education, in a center based in the city of Granada.

Results: The results show that both the methodology employed through the use of ICT and the neurophysiological development of each student influence their learning of English as a second language. Equally, attention was also found to be related with the learning of English. On the other hand, motivation to learn was found to be greater in students learning via ICT.

Discussion and conclusions: Thus it can be concluded that a methodology based in ICT favors acquisition of second languages, as does the motivation of the student for learning. Likewise, those students with more advanced neurophysiological development and who score higher for attention find it easier to learn English.

Key words: Information Computer Technology (ICT), learning a second language, English, motivation, attention, neurophysiological development, executive function.

Introduction

Currently, the impact of new technologies on society has generated changes in the better part of human activity (Hernández and Muñoz, 2012). The emerging 'information society' and technological development have also led to changes in the educational process (Hubackova and Ruzickova, 2011). The last few years have resulted in a greater preoccupation with effectively using the diverse technological and internet-based resources available at all levels of education, in formal and informal contexts alike. A multitude of teachers and investigators have become interested in the influence of new technologies on learning and, more specifically, in the use of information and communication technologies (ICT) in foreign-language teaching (Ghasemi and Hashemi, 2011; Røkenes and Krumsvik, 2016).

According to Ghasemi and Hashemi (2011), ICT is defined as a diverse group of technological tools and those resources used in order to communicate, create, diffuse, store and manage information. The integration of such technologies into the education sector has generated variations in processes of teaching and learning (Yunus, Nordin, Salehi, Embi, and Salehi, 2014).

In the sixties, the first information system appeared – and since then diverse strategies have been employed to incorporate ICT at different levels of education (Badia, Meneses, and Sigalés, 2013; Nordin, Embi, and Yunus, 2010; Nordin, Hamzah, Yunus, and Embi, 2010; Salehi and Salehi, 2012; Yunus, Nordin, Salehi, Embi, and Salehi, 2013; Yunus, Salehi, and Chenzi, 2012). Despite the fact that the introduction of ICT was made many decades ago, there is still a great deal of controversy about its impact on students' learning. The use of ICT as an educational tool presents several limitations, such as: elevated cost, limited availability of equipment, lack of knowledge about its use, and the reticence of some teachers to accept ICT as an educational resource (Harutyunyan, Moldoveanu, Moldoveanu, and Asavei, 2015).

However, the reason for which ICT is acquiring such importance in the educational sector results from diverse investigations showing that it improves the quality of education; permitting students to quickly access a large quantity of information and increasing students' interest in and motivation towards learning, among other things (Ghasemi and Hashemi, 2011).

Therefore, there is a need to carry out systematic investigations around the impact of ICT on education since, despite the fact that these technologies have been successfully integrated in the classroom, little is known about their direct impact – above all on academic achievement (Condie and Munro, 2007). The majority of studies carried out have been focused on analyzing the relation between ICT and improved motivation (Passey, Rogers, Machell, and McHugh, 2004; Yunus, Chua, Maimun, and Rizauddin, 2010); a variable which is considered fundamental to academic achievement and improved learning.

On the other hand, in recent years domination of other languages has become a primary objective in academic contexts (Matsuda and Friedrich, 2011; McKay, 2002). According to Abdel-Rahman (2009), Mandarin and English are the most-used languages, English being used as an international language thanks to globalization and competition between nations (Faradilla, 2010). Speaking of English as an 'international language' makes reference to a term which describes the function and use of English in multilingual contexts (Friedrich and Matsuda, 2010; Matsuda and Friedrich, 2011). It is in this light that the need to introduce English in schools, as part of planned studies, begins to emerge (Shamsudin, 2009), since its being an international language highlights the importance of its teaching (Emir, 2010).

Nonetheless, at this moment the greater part of the Spanish population are not competent in using English, despite the fact that is included in curriculums from the first year of primary schooling (Sekharan et al., 2014). This could be due to the passivity of the instruction and assessment that students are subjected to, which does not take into consideration differences between individuals and the need to tailor teaching to each individual student (Arteaga, 2011; Prato and Mendoza, 2006). This all generates feelings of frustration and poses a great challenge for the teacher, since several publications and conferences have recognized that the current way of teaching English is inadequate – but have done so without offering solutions to this problem (Matsuda and Friedrich, 2011).

For several years, the teaching of second languages has been based in traditional teaching methods. However, the teaching of today must take new methods into account, such as the use of ICT in the classroom (Hubackova and Ruzickova, 2011).

Thus, owing to the multiple opportunities presented by ICT, this technology could prove a transformative pedagogical tool in the educational field. Several studies have shown that the use of ICT in the classroom optimizes learning of languages and improves students' motivation and interest (Yunus et al., 2010). In this spirit, Passey et al. (2004) carried out a study which found that the use of ICT in the classroom generates high levels of motivation to achieve in students.

Furthermore, the use of ICT for teaching English helps to enhance skills in reading, writing, speaking and listening. In a study carried out by Harrison et al. (2002), it was found that ICT contributes to: greater commitment from students; reflection on and analysis of the subject studied; and that it favors the development of competencies associated with communication.

Muslem and Abbas (2017) mention a series of opportunities to use ICT as part of the teaching and learning process, particularly in English classes. The first, as has been previously mentioned, is for motivation. Granito and Chernobilsky (2012) recognize that technology has the potential to be a powerful educational tool, and it is likely that students who use technology will keep on carrying out a task for longer periods of time. For example, in listening exercises, the teacher can use the internet to find rich sources of model speech from native speakers, which not only serve to help students with pronunciation but also act as support for those teachers who feel less than secure with their own linguistic skills. In consequence, Silviyanti (2014) discovered that the use of YouTube appears to be interesting and beneficial to students, enthusing them more, and thus making them more motivated to watch a video and later practice the pronunciation of words in imitation of native speakers (instead of only practicing listening through use of conventional audio recordings).

The second is collaborative learning. Domalewska (2014) states that collaborative learning, supported by technology, can prompt language development because students learn through social interaction. For example, Silviyanti and Yusuf (2015) found that blogs encouraged students to make comments on the work of others, to share their experiences, to reflect on their own work and on that of their classmates, and to thus develop their critical thinking skills.

The third is cultural awareness. Hollenbeck and Hollenbeck (2009) state that ICT provides teachers with tools with which to address inequity and access problems, to accelerate their students' linguistic and conceptual development, to offer support to those students who learn in different ways, and to create authentic and significant learning experiences. Technology can be adapted for cultural awareness, permitting students to interact and fully participate in their own learning, whilst gaining linguistic skills and cultural awareness.

One the other hand, the use of ICT in English classrooms also has several disadvantages. Kolbakova (2014) suggests that the use of ICT in the teaching and learning process adds work and creates additional struggle for teachers seeking to satisfy the needs of each and every student in their class. ICT might not be appropriate for every student, or for every situation or purpose; students may also require considerable training in order to use technologies successfully. Other barriers to using ICT include classroom management and the risk of distraction. One of the problems most commonly faced by teachers with regards to technology occurs when students copy and paste from internet sources, also known as plagiarism. The ability to rapidly obtain large amounts of information from the internet can make students apathetic when it comes to doing their homework. Yunus et al. (2013) explain in greater detail that, if students' reading skills are developed solely by moving across a computer screen, this can result in an inaccurate understanding of the reading's content.

However, ICT as a classroom tool for teaching and learning a foreign language is inevitable in this day and age, as such technologies already form part of our daily life. Rabah (2015) has strongly contended that the use of technology in learning, which is already a powerful and flexible learning tool that is necessary to confront the challenges of globalization, promotes the economic status of a country and motivates and helps its students to learn.

Another variable of particular relevance to learning is neurophysiological maturity, defined as the developmental maturity and level of organization that permits the development of behavioral and cognitive functions in line with a person's chronological age. When addressing the concept of neurophysiological maturity, harmonic and progressive processes of development across different dimensions are included, such as: laterality, visuoperception, executive function, rhythm, and perceptual abilities – attention, memory and language (Portellano, Mateos, Martínez, and Granados, 2000).

Neurophysiological disorders are frequently associated with academic failure and difficulties in learning. For this reason, looking into a student's neurophysiological development makes it possible to better establish their educational chances, with the aim of better supporting the student within the classroom and preventing academic failure (Diamond, 2013; Portellano, Mateos and Martínez, 2012; Santa-Cruz and Rosas, 2017).

In this same vein, Martínez (2015) maintains that there is a relation between neurophysiological development and learning – and, by extension, with the learning of second languages. However, it is currently not known whether there are any studies evidencing the impact of neurophysiological maturity on the learning of second languages: hence the interest in including this variable within the present study.

On the other hand, attention – defined as the mechanism directly implicated in the activation and functioning of processes and operations of selection, distribution and maintenance of psychological activity (García-Sevilla, 1997) – also plays a very important role in the learning of any material, since it is considered a vital component for the selection and manipulation of information (Laberge, 1995; León, 2008). Traditionally, attention has been considered as a good predictor of academic success. In this way, those students showing an ability to maintain their attention well can hope to obtain, in turn, better academic results. However, the most restless student, with a greater tendency to become distracted, can expect to achieve lower scores in tests of attention and a worse academic showing (Boujon and Quaireau, 1999). Likewise, students with attentional deficits experience difficulties in acquiring reading and writing skills (González-Castro, Álvarez, Núñez, González-Pienda and Álvarez, 2008; León, 2008): prerequisites for any learning curriculum.

For this reason, the role played by attention in the acquisition of a second language has become a topic of great interest in the scope of the investigation (Nelson, 2011; Robinson, 2003). In this line, Nelson (2011) showed that attention could have a fundamental role in the learning of second languages.

Objectives and hypothesis

Taking into account the importance that the use of ICT, attention, neurophysiological maturity and motivation have when it comes to learning, the current investigations aims to: a) analyze the influence of ICT on the learning of second languages – concretely, on learning English; b) test whether there is a relationship between neurophysiological maturity and the learning of second languages; c) discover what role is played by attention in the learning of second languages; and d) indicate whether learning second languages through ICT influences students' motivation.

Taking into account the objectives of the investigation and the theoretical review carried out, it is hoped that a) a student who receives teaching through ICT will obtain better results in learning a second language than their peers receiving traditional teaching; b) the learning of a second language will improve when the student's level of neurophysiological maturity is higher; c) a high score for attention will be related with better learning of second languages; and d) a student learning through ICT will be more motivated to acquire a second language than a student receiving traditional teaching.

Method

Participants

70 students, 35 girls and 35 boys, aged between 10 and 11 years old, enrolled in the fifth year of primary education in a center located in the city of Granada participated in the study. They were sorted into groups for the experiment: experimental group 1 was formed of 25 students, who received their English teaching by means of ICT. Experimental group 2 was made up of 45 students, who were taught English according to traditional teaching methodology. The gender distribution of students across the groups is detailed in Table 1.

Table 1. *Distribution of the sample by experimental status and sex*

	Boys		Girls		Total	
Status	*n*	*%*	*n*	*%*	*n*	*%*
Experimental group 1	12	17.14	13	18.58	25	35.72
Experimental group 2	23	32.86	22	31.43	45	64.29
Total	35	50	35	50	70	100

Instruments

The present study uses various dependent variables related with neurophysiological maturity (language, visuoperception, executive function, memory, rhythm and laterality), attention, motivation and the learning of English. The points of evaluation (pre-test—post-test), the sex (boy—girl) and the status of the participants (experimental 1—experimental 2) were treated as independent variables or groups.

Learning English

In order to evaluate students' levels of English-learning, two written tests ('The Mysterious Egypt') were used at each point of evaluation (pre-test—post-test) to evaluate their grasp of the material. The tests were constructed ad-hoc by the teacher, with a similar format to tests taken by students throughout the academic year.

The tests consisted of three broad skill areas:

- *Listening* (composed of three activities): measured aural comprehension of vocabulary and grammar, studied in unison by means of: a) identifying images through listening to phrases in English related to said images; b) identifying images after having listened to a story in English; and c) selecting the correct answer from a multiple-choice question after having listened to a new story in English.
- *Reading* (formed of two tests): measured reading comprehension of a given text in English by means of: a) a multiple-choice questionnaire (3 possible answers); and b) a series of 8 free-response questions.
- *Writing* (made up of 4 tests): measured vocabulary and aspects of grammar, worked in unison throughout by identifying images and completing phrases and texts in English.

Neurophysiological maturity

Neurophysiological maturity was measured by the *Neurophysiological Maturity educational Questionnaire: CUMANES de Portellano et al.* (2012). This questionnaire permits a

global evaluation of neurophysiological development in primary-school students. According to the authors, the test shows a Cronbach's alpha of .79 and is composed of a series of 12 tests grouped in 6 sections:

Section 1: Language. Consisting of 6 tests:

- Audioverbal understanding (α=.67): allowing an analysis of comprehensive language, sustained attention, and verbal memory.
- Understanding of images (α=.80): evaluating comprehensive language, and sustained attention.
- Phonemic fluency (α=.64): evaluating expressive language, verbal fluency, executive function, and working memory.
- Semantic fluency (α=.64): allowing an evaluation of expressive, verbal fluency; executive function; and working memory.
- Lexical reading comprehension (α=.61): evaluating reading fluency, sustained attention, and verbal memory.
- Dictation (α=.81): evaluating short-term memory, sustained attention, psychomotor efficiency, visuoperception, and graphomotor functioning.

Section 2: Visuoperception. (α=.85): allowing the evaluation of spatial structuring, constructive praxia, spatial orientation and graphomotor functioning.

Section 3: Executive function: evaluating programming capacity, sustained attention, divided attention, working memory, prospective memory, the capacity to improve motor perception, mental flexibility, and inhibitory capacity.

Section 4: Memory. Consisting of two tests:

- Verbal memory (α=.68): evaluating explicit memory, short-term memory, and semantic memory.
- Visual memory (α=.63): evaluating explicit memory, short-term memory, non-verbal memory, and spatial organization.

Section 5. Rhythm (α=.83): evaluating sequencing skills, sensory memory, short-term memory, implicit memory, and sustained attention.

Section 6. Laterality (α=.85): evaluating language dominance, neurophysiological maturity, body schema, spatial organization, and motor skills.

The reliability indices of the text for the study participants were similar to those presented in the original test.

Attention

Attention was evaluated through the 'CARAS-R. Test of perception of differences' questionnaire by Thurstone and Yela (2012). The questionnaire allows the evaluation of perceptive and attentional aptitudes through 60 graphic elements, comprising faces drawn with basic strokes. The student must identify the different ('odd-one-out') face among three given faces and cross it out. The questionnaire can be applied individually or collectively, and for the purposes of this study it was carried out collectively, with a 3-minute time limit. The questionnaire allows us to obtain four scores:

1. Correct answers (A). The subject's total number of correct answers. They are given a point for each of the faces that are crossed out on their test paper (correctly answered). The total number of correctly marked faces will be the number of correct answers.
2. Errors (E). The subject's total number of errors. Each of the crosses that the subject has marked on their paper that does not correspond to the 'different' face of the three is counted. The total number of erroneous marks will be the number of errors.
3. Net correct answers (A-E). The total remaining when the total number of the subject's errors is subtracted from total number of the subject's correct answers. In this way a more precise measure of the efficacy of their answers in the test is obtained.
4. Index of Control of Impulsivity (ICI). This is calculated by dividing the number of net correct answers (A-E) by the total number of answers given by the subject (A+E).

Motivation

Motivation was evaluated by means of a question constructed ad hoc, with an answer on the Likert scale of ten points: 1 equaling *nothing* and 10 equaling *very*. The question measures the student's motivation towards the methodology employed by the English teacher,

at the time of study. Concretely, the question posed to the students was the following: 'How much did you like how you were taught English this term and resources you used in class?'

Procedure

In carrying out the current study, first of all permission was sought from the center involved. Once the necessary permissions were obtained, from teaching staff as well as the students' parents, the investigation's objectives were explained to the faculty for the fifth primary-school year. Once informed consent was gained, we proceeded to explanation and completing the questionnaires with the students. The questionnaires were completed by students in different sessions.

The questionnaire used to evaluate learning of English was administered by the center's English-teaching specialist in two phases, pre-test and post-test. The tests used in both phases differed in the order of each of the activities, and in the texts used to test oral and written comprehension. This was done with the aim of not generating 'learning by memory'. The interval between both phases was three weeks, during which an intervention was carried out in both groups. As has been previously outlined, group 1 differed from group 2 in terms of the methodology used to teach English. Concretely, group 1 was taught English by means of ICT (use of computers, interactive games, DVDs, CD-ROMs, videogames and websites) and group 2 was taught by a traditional methodology (based on the use of textbooks and files).

Amongst the activities used in group 1, a videogame created for this investigation featured prominently. It is an online game in which the teacher divides students into working groups and assigns to each a specific set of vocabulary or language category. In the game, the student meets rivals whom they have to disarm by translating words from Spanish to English, and vice versa, or by correctly using grammatical phrases. The vocabulary words and the grammatical phrases were created by the teacher, who ensures that they are updated once the student has acquired them. When the student is correctly using the grammar or the words, they gain points and move on to a new screen. With these points, the student has the option to go to a vault and exchange their points for accessories. Furthermore, correct use of English allows the student to go up a level and improve their character. Likewise, the student can continue playing at home and choose a specific rival to confront.

Another salient activity was the running of several videoconferences between the students and students from a school in Manchester. In these conference different topics were proposed (for example: health, culture, recycling) and students had to ask and answer questions in English on the proposed topic.

Alongside this, the *Neurophysiological Maturity educational Questionnaire* was carried out in the pre-test phase on a one-on-one basis, following the order established by the questionnaire's authors for each of the tests. The test was administered by the center counsellor in separate sessions, taking place in the first hours of the school day, in order to avoid the effect that tiredness might have on the participating student.

The *Test of perception of differences* was administered in the pre-test phase and the motivation questionnaire in the post-test phase. Both questionnaires were administered collectively by evaluators trained to carry out this task.

Once the questionnaires were completed by the student, we proceeded to analyze the results and to write the report. Lastly, the center was informed about the results obtained.

Data analysis

Taking the objectives and hypotheses of the current investigation as a premise, the methodology used was *quasi experimental*, with two experimental groups (experimental group 1 and experimental group 2) and two moments in time (pre-test and post-test). It was not possible to randomly assign students to the experimental conditions – ready-formed class groups were used.

In relation to the preliminary analysis, and also to obtain measures of central tendency and dispersion, test *t* was carried out on independent samples in order to test the differences and similarities between experimental group 1 and experimental group 2 in the pre-evaluation phase. (The samples used were more appropriate owing to the homogeneity of their variances).

Later, a Mixed Model ANOVA was carried out, in which the moment of evaluation (pre-test—post-test) was included as an intra-group factor, and the condition (experimental

1—experimental 2) as an intergroup factor. Following this, the *t* test was carried out on independent samples to test in which moment of the evaluation the possible differences between the groups were to be found.

Likewise, Pearson correlations were used to analyze the relation between English learning and the intrapersonal variables analyzed – these being neurophysiological maturity, attention, and motivation.

The different analyses were carried out with the statistics program *Statistical Package for the Social Sciences* (SPSS), version *Statistic* 20.0 for Windows.

Results

English learning and methodology

Owing to the fact that the participants in the investigation had not been randomly assigned to the two experimental conditions, a difference of means test was carried out in order to test if both groups started from similar levels of English in the pre-evaluation phase. The results show that, before the intervention phase, both groups obtained similar scores in tests of *listening* ($t_{(68)}=1.03$, $p=.308$), *reading* ($t_{(68)}=1.69$, $p=.096$), *writing* ($t_{(68)}=1.40$, $p=.167$), and in total ($t_{(68)}=.19$, $p=.849$).

On the other hand, the results obtained in the Mixed Model ANOVA in the English-learning variables show principle effects for the time factor (pre-test—post-test) on all of the English-learning variables analyzed: *listening* $F_{(1.66)}=231.14$, $p=.000$; *reading* $F_{(1.66)}=41.84$, $p=.000$; *writing* $F_{(1.66)}=310.80$, $p=.000$; and in the total English test $F_{(1.66)}=371.49$, $p=.000$. Students in both groups (experimental and control) obtained significantly higher marks in the post-intervention phase (see Table 2). Higher effect sizes were observed for English-learning as a whole (eta^2=.85) and for the *listening* (eta^2=.78) and *writing* tests (eta^2=.83), and an average effect size for the *reading* test (eta^2=.39).

Table 2. Means and standard deviations for the variables of learning English in pre- and post-evaluation phases

| | Experimental 1 | | | | Experimental 2 | | | | Total | | | |
| | Pre | | Post | | Pre | | Post | | Pre | | Post | |
	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd
Listening	.38	.23	.79	.16	.43	.22	.66	.17	.41	.22	.71	.18
Reading	.47	.17	.65	.22	.39	.18	.50	.22	.42	.18	.55	.23
Writing	.13	.12	.63	.22	.17	.11	.40	.21	.15	.12	.48	.24
Total	.32	.13	.68	.17	.33	.15	.52	.18	.33	.14	.58	.19

The results show significant interaction effects between the time factors of evaluation (pre-test—post-test) and condition (experimental 1—experimental 2) in the variables of English learning: *listening* $F_{(1.66)}=18.14$, $p=.000$, *writing* $F_{(1.66)}=43.62$, $p=.000$, and the total test of English $F_{(1.66)}=37.39$, $p=.000$. The effect sizes of the interaction are moderate for the total of the English test (eta^2= .36), and for the *listening* (eta^2= .22) and *writing* tests (eta^2= .40). However, the effect size is low for the *reading* test (eta^2= .04).

In line with the interaction effects, the mean difference test, carried out on independent samples, reveals significant differences between the two experimental groups in the post-evaluation phase. The boys and girls from experimental group 1 obtained higher marks than their peers in experimental group 2 in *listening* $t_{(69)}=2.84$, $p=.006$, *writing* $t_{(69)}=4.22$, $p=.000$ and in the total English test $t_{(69)}=3.67$, $p=.000$. On the other hand, interaction effects were not found in the *reading* test $F_{(1.66)}=2.58$, $p=.113$, although the mean difference test revealed that there were significant differences between experimental group 1 and experimental group 2 in the post-evaluation phase. Students in experimental group 1 obtained higher marks than their peers in experimental group 2 in the *reading* test $t_{(69)}=2.65$, $p=.010$.

English learning and neurophysiological maturity

With the aim of analyzing the relation that exists between neurophysiological maturity and English learning, a Pearson correlation was carried out between these two variables (see Table 3). The data obtained signal the presence of a positive and significant correlation between *listening* and audioverbal comprehension. In the same fashion, *listening* positively and significantly correlated with image comprehension, leximetric reading comprehension (words per minute), with dictated writing, and with total neurophysiological maturity. Likewise, the *listening* variable correlated negatively and significantly with executive function (time in sec-

onds) and executive function (number of errors). No other significant correlations between *listening* and the rest of the Cuman variables – such as phonemic and semantic fluency, leximetric comprehension (correct responses), visuoperception, verbal and visual memory, rhythm, or with manual, ocular or breech laterality.

Table 3. *Pearson Correlations between English learning and neurophysiological maturity*

Neurophysiological maturity	English learning			
	Listening	*Reading*	*Writing*	Total
Audioverbal comprehension	.31*	.27*	.14	.30*
Image comprehension	.53**	.24*	.29*	.44**
Phonemic fluency	-.01	-.09	.08	-.02
Semantic fluency	.16	-.01	.13	.11
Leximetric comprehension (Correct answers)	.-.01	.15	-.05	.04
Leximetric comprehension (Words per minute)	.40**	.36**	.35**	.45**
Dictated writing	.38**	.45**	.36**	.47**
Visuoperception	.11	.19	.10	.16
Executive function (Time in seconds)	-.31**	-.37**	-.38**	-.41**
Executive function (Number of errors)	-.26**	-.26*	-.23	-.30*
Verbal memory	.14	.03	.09	.11
Visual memory	.16	-.02	.04	.08
Rhythm	.21	.12	.03	.16
Manual laterality	.05	-.02	-.02	.01
Ocular laterality	-.01	-.03	-.01	-.02
Breech laterality	.05	.07	.06	.07
Total neurophysiological maturity	.52**	.34**	.33**	.49**

*p<.05 (bilateral); **p< .01 (bilateral)

On the other hand, it was observed that the *reading* test correlated positively and significantly with audioverbal comprehension, image comprehension, leximetric comprehension (words per minute), dictated writing, and with total neurophysiological maturity. In the same manner, negative and significant correlations were observed with executive function (time in seconds) executive function (number of errors). No significant correlations were found between *reading* and the variables of neurophysiological maturity related with phonemic and semantic fluency, leximetric comprehension (correct responses), visuoperception, verbal and visual memory, rhythm, or with manual, ocular or breech laterality.

From another side, the data indicate that *writing* correlated positively and significantly with image comprehension, leximetric comprehension (words per minute), dictated writing

and with total neurophysiological maturity. In the same manner, negative and significant correlations were found with executive function (time in seconds). No significant correlations were found between *writing* and those variables related with audioverbal comprehension, phonemic and semantic fluency, leximetric comprehension (correct responses), visuoperception, executive function (number of errors), verbal and visual memory, rhythm, or with manual, ocular or breech laterality.

The total mark obtained in the English test correlated positively and significantly with audioverbal comprehension, with image comprehension, with leximetric comprehension (words per minute), with dictated writing, and with total neurophysiological maturity. In the same manner, negative and significant correlations were found between the total mark for the English test with executive function (time in seconds) and executive function (number of errors). No statistically significant correlations were found with those variables of neurophysiological maturity related with phonemic and semantic fluency, leximetric comprehension (correct responses), visuoperception, verbal and visual memory, rhythm, or with manual, ocular or breech laterality.

English learning and attention

Table 4 shows the results obtained by the Pearson correlation carried out between the learning of English and attention. In this manner, significant positive correlations can be observed between all the English-learning variables analyzed (*listening, reading, writing* and the total obtained in the English test) and the number of correct answers. Equally, a positive and significant correlation was produced between the English-learning variables and the net number of correct answers. In contrast, no significant correlations were found between the English-learning variables and errors committed, nor with the impulsivity control index.

Table 4. *Correlations between English learning and attention*

Attention	English learning			
	Listening	*Reading*	*Writing*	Total
Correct answers	.38**	.37**	.43**	.46**
Errors	-.01	-.08	.01	-.04
Net correct answers	.37**	.37**	.41**	.45**
Impulsivity control index	.03	.14	.06	.09

*p<.05 (bilateral); **p< .01 (bilateral)

English learning and motivation

The means and standard deviations in motivation are shown in Table 5. The results obtained in the mean difference test of motivation according to condition (experimental 1 and experimental 2) in the post-intervention phase show significant differences between both groups, with experimental group 1 obtaining a better score for motivation than experimental group 2 $t_{(51.18)}$=19.18, p=.000. The effect size of the difference was obtained by means of the Eta-square and correlation co-efficient, with the results showing a very high effect size eta^2=.75 y r=.90.

Table 5. *Means and standard deviations in motivation*

	Experimental 1		**Experimental 2**		**Total**	
	M	*Sd*	*M*	*Sd*	*M*	*Sd*
Motivation	9.80	0.41	3.74	2.07	5.87	3.36

Discussion and conclusions

First off, the results of this study show that, independently of whether the method used by the professor was based on traditional teaching methods or was augmented with new technologies, students had improved their learning after the educational intervention. Students from both experimental groups obtained significantly better marks after the teaching sessions on the subject. Nonetheless, and in spite of those studies which exist questioning the efficacy of ICT in learning (Condie y Munro 2007; Cuban y Kirkpatrick, 1998), the preliminary analyses confirm the first of the opening hypotheses of this study: that teaching English through ICT improves student learning when compared with traditional teaching. These results were also found in the area of mathematics in another study carried out by Cheung and Slavin

(2013); who found that ICT produced positive effects in comparison with traditional teaching in mathematical learning. In this same vein, Cox et al. (2003), found a positive effect of ICT on students' learning of basic subjects. However, they indicated that this effect was dependent on the technological resources employed and the subject in question.

These findings are congruent if one takes into consideration the fact the emergence of technologies in the educational sector has generated an increase in both motivation and student interest in the process of learning, and has promoted the development of greater autonomy and competence within a society in a state of continual change and transformation. The quantity of time that students dedicate to using certain technologies (mobile phones, internet, social media and videogames) out of school contexts, and the variety of digital and audiovisual resources that are being developed, lead teachers to consider the need to incorporate these technologies into their teaching methods. To do so, developing and making use of technological resources (such as videogames) which enhance student learning, as much within as outside the classroom, becomes a vital aspect of their practice to be considered by teachers. Furthermore, the methodology of teaching through ICT favors student autonomy and collaboration, and the creation of a discourse within and without the classroom which enhances learning and, at the same time, makes it more likely that this learning takes a more playful and independent form. In this vein, Ghasemi and Hashemi (2011) indicate that learning English as a second language, through the use of ICT, not only improves student motivation but enhances interactive learning, the ability to adapt to students' different learning styles, and offers greater opportunities to develop creativity. In this way, students will be provided with the opportunity to become active participants in their own English learning, through the use of videogames, chats, and other resources.

Elsewhere, the results of the study confirm the second hypothesis that there already exists a positive relationship between a student's neurophysiological maturity and their English learning. Those students who obtained higher marks in the *listening*, *reading* and *writing* tests also obtained higher scores for neurophysiological maturity – and in several of the variables that comprise it. More specifically, the results show that there are certain variables of neurophysiological maturity that have a greater influence on English learning (Keane, Keane and Blicblau, 2016). In this sense, it seems that both audiovisual comprehension – such as image comprehension, reading speed, and the ability to copy words and phrases – and executive function are the variables which have the greatest influence on learning English as a sec-

ond language. However, other variables such as phonemic and semantic fluency, visuoperception, memory, rhythm, or laterality do not appear to have a relation with English learning.

In a similar manner, as would happen with any learning content, attention is shown to have a relation with English learning: confirming the third hypothesis of this study. Those children who had high scores in the English tests carried out also obtained high scores in the number of correct answers, and low scores for errors, in the attention questionnaire. As Ortiz (2009) indicates, one of the fundamental roles of attention in the educational field it its influence on behavioral control, learning, cognitive processes and, in general, on activities related with school life. In this vein, Vassilopoulou and Mavrikaki (2016) carried out a study in which they showed that the use of ICT managed to attract students' attention, and kept them more active within the learning process than the use of traditional methodology. For this reason, it seems of fundamental importance to develop an active methodology supported by ICT, given that this type of methodology favors both processes of attention and student learning.

Elsewhere, the results confirm the fourth hypothesis, in showing that those students who learn English through ICT demonstrate greater motivation towards the material they have been taught than those students receiving traditional teaching. Similar results have been found in other studies, like that carried out by Tüzün, Yılmaz-Soylu, Karakuş, İnal and Kızılkaya, (2009), although in this case the subject being taught was Geography. The authors showed that, in a comparison of student motivation in Geography using traditional methodology versus another based in the use of videogames as a technological resource, those students who learned through the use of videogames showed significantly greater motivation, as well as better marks than those who received traditional teaching.

Likewise, a methodology based on ICT for teaching second languages improves interest towards learning and facilitates access to other cultures. It also improves interaction between students, and generates a greater sense of independence towards one's own learning; as well as greater motivation towards the same. All of these positive effects suggest that incorporating ICT as a tool in educational environments would greatly serve to support and improve acquisition of second languages (Adedokun-Shittu y Shittu, 2015).

In this way, the following conclusions can be extrapolated from the present investigation: a) the methodology employed influences learning English as a second language. Specifi-

cally, the use of ICT improves the acquisition of English in comparison with traditional teaching; b) that there is a relation between neurophysiological maturity and English learning, with executive function, audiovisual and image comprehension, reading speed and the ability to copy phrases and words having particular relevance; c) that, as occurs in other areas of knowledge, attention is fundamental for the acquisition of English; and d) student motivation improves when teaching based in ICT is used versus traditional teaching.

However, the limitations of this study should be taken into account: much of which are related with the nature of the study's design and the way in which it was executed. It was not possible to randomly assign students to experimental group 1 and experimental group 2; and thus causal relations could not be established, nor other types of individual variables controlled for – such as the cultural group or ethnicity of participants, or their previous performance. Nonetheless, an attempt was made to control other kinds of limitations associated with cuasi-experimental designs through the use of two distinct experimental groups and different temporal moments for the evaluation of the subjects. Likewise, a *t* test was carried out to see if there were any differences between experimental groups 1 and 2 before the intervention, with the aim of taking initial differences into consideration and carrying out the relevant analyses.

Furthermore, it cannot be overlooked that the study was carried out with a very reduced number of subjects and in a specific center in the city of Granada. For this reason, the study's external validity is limited and it is very complicated to extract firm conclusions and to generalize the results to other contexts. Likewise, motivation was evaluated through a single question, aimed at gauging satisfaction.

In the same fashion, another limitation comes from the use of a cross-sectional study. Specifically, the effects of the interventions are measured in the short-term, preventing us from being able to determine the true, longer-term impact of the use of ICT in teaching.

Taking this into perspective, in future investigations it would be interesting to compare how the use of different ICT resources – such as, for example, videogames vs interactive whiteboards – influence English learning and student motivation in different ways. Equally, it would be interesting to carry out a longitudinal analysis on the effect of using ICT at all edu-

cational stages and across different subjects. Likewise, a study could also analyze if ICT encourages the maintenance of attention and, in this way, enhances learning.

References

Abdel-Rahman, A. (2009). Attitudes of Jordanian College Students towards Learning English as a Foreign Language. *College Student Journal*, *43*(2), 682-694.

Adedokun-Shittu, N.A. and Shittu, A.J.K. (2015). Assessing the impacts of ICT deployment in teaching and learning in higher education: Using ICT impact assessment model. *Journal of Applied Research in Higher Education, 7*(2), 180-193. doi:10.1108/JARHE-02-2013-0012

Arteaga, C. (2011). Uso de las TIC Para El Aprendizaje del inglés en la Universidad Autónoma de Aguascalientes. *Apertura*, *3*(2), 1-13.

Badia, A., Meneses, J. and Sigalés, C. (2013). Percepción de los docentes sobre los factores que afectan el uso educativo de las TIC en el aula equipada de tecnología. *Electronic Journal of Research in Educational Psychology*, *11*(31), 787-808. doi:10.14204/ejrep.31.13053

Boujon, C.H. and Quaireau, C.H. (1999). *Atención, aprendizaje y rendimiento escolar.* Madrid: Narcea.

Cheung, A.C. and Slavin, R.E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: a meta-analysis. *Educational Research Review, 9*, 88–113. doi:10.1016/j.edurev.2013.01.001

Condie, R. and Munro, B. (2007). *The impact of ICT in schools – A landscape review*. London: Becta.

Cox, M., Abbott, C., Webb, M., Blakeley, B., Beauchamp, T. and Rhodes, V. (2003). *ICT and attainment: A review of the research literature. ICT in Schools Research and Evaluation Series.* London: Becta.

Cuban, L. and Kirkpatrick, H. (1998). Computers make kids smarter–right? *Technos, 7*(2), 26-31.

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64,* 135-168. doi:10.1146/annurev-psych-113011-143750

Domalewska, D. (2014). Technology-supported classroom for collaborative learning: Blogging in the foreign language classroom. *International Journal of Education and Development using Information and Communication Technology, 10*(4), 21-30.

Emir, S.E. (2010). A Study on the Affective Attitudes of Students at Gazi Educational Faculty towards English Classes. *Ekev Academic Review, 14*(45)*,* 129-136.

Faradilla, E. (2010). Attitude towards Use of ICT and Its Actual Level of Use in English Language Teaching in Miri, Sarawak. *Asian Social Science*, *8*(11), 8-12.

Friedrich, P. and Matsuda, A. (2010). When five words are not enough: a conceptual and terminological discussion of English as a lingua franca. *International Multilingual Research Journal*, *4*, 20–30.

García-Sevilla, J. (1997). *Psicología de la atención.* Madrid: Síntesis.

Ghasemi, B. and Hashemi, M. (2011). ICT: New wave in english language learning/teaching. *Procedia - Social and Behavioral Sciences, 15*(0), 3098-3102. doi:10.1016/j.sbspro.2011.04.252

González-Castro, P., Álvarez, L., Núñez, J.C., González-Pienda, J.A. and Álvarez, D. (2008). La aplicación de una estrategia computarizada para enseñar y aprender matemáticas en Educación Primaria. *European Journal of Education and Psychology, 1*(1), 21-38.

Granito, M., and Chernobilsky, E. (2012). The effect of technology on a student's motivation and knowledge retention. *Proceedings of Northeastern Educational Research Association Conference (NERA, 2012)* (pp. 1-22). Paper 17. Recuperado de http://digitalcommons.uconn.edu/nera_2012/17

Harrison, C., Comber, C., Fisher, T., Hawe, K., Lewin, C., Lunzer, E., … Watling, R. (2002). *ImpaCT2: The Impact of Information and Communication Technologies on Pupils Learning and Attainment. ICT in Schools Research and Evaluation Series.* Londres: Becta.

Harutyunyan, P., Moldoveanu, A., Moldoveanu, F. and Asavei, V. (2015). Health-related impact, advantages and disadvantages of ICT use in education, compared to their absence in the past. *The International Scientific Conference eLearning and Software for Education, 1*, 557-563.

Hernández, L.K. and Muñoz, L.F. (2012). Usos de las tecnologías de la información y la comunicación (TIC) en un proceso formal de enseñanza y aprendizaje en la Educación Básica. *Zona Próxima, 16*, 2-13.

Hollenbeck, J. and Hollenbeck, D. (2009). Using technology to bridge the cultures together in the multicultural classroom. In D. P. French, (Ed.). *Technology in the College Science Classroom* (pp. 1-6). Stillwater: Oklahoma State University.

Hubackova, S. and Ruzickova, M. (2011). Experience in foreign language teaching with ICT support. *Procedia Computer Science, 3*(0), 243-247. doi:10.1016/j.procs.2010.12.041

Keane, T., Keane, W.F. and Blicblau, A. (2016). Beyond traditional literacy: Learning and transformative practices using ICT. *Education and Information Technologies, 21*(4), 769-781. doi:10.1007/s10639-014-9353-5

Kolbakova, F. (2014). *The Use of ICT among the Teachers of English in Estonia by Comparison with Europe and Asia* (Master's thesis). University of Tartu, Tartu, Estonia. Recuperado de http://dspace.ut.ee/bitstream/handle/10062/46990/Master's_Thesis_Kolbakova.pdf

Laberge, D. (1995). *Attentional processing*. Londres: Harvard University Press.

León, B. (2008). Atención plena y rendimiento académico en estudiantes de enseñanza secundaria. *European Journal of Education and Psychology, 1*(3), 17-26.

Martínez, I. (2015). *Relación entre el desarrollo neuropsicológico y el rendimiento escolar en Primaria.* (Tesis de maestría). Universidad Internacional de La Rioja, Logroño.

Matsuda, A. and Friedrich, P. (2011). English as an international language: A curriculum blueprint. *World Englishes, 30*(3), 332-344. doi:10.1111/j.1467-971X.2011.01717.x

McKay, S. (2002). *Teaching English as an International Language: Rethinking Goals and Approaches*. Oxford: Oxford University Press.

Muslem, A., and Abbas, M. (2017). The effectiveness of immersive multimedia learning with peer support on English speaking and reading aloud. *International Journal of Instruction, 10*(1), 203-218.

Nelson, R. (2011). Vigilance, expectancy, and noise: Attention in second language lexical learning and memory. *Second Language Research, 27*(2), 153-171. doi:10.1111/j.1467-971X.2011.01717.x

Nordin, N., Embi, M.A. and Yunus, M.M. (2010). Mobile learning framework for lifelong learning. *Procedia –Social and Behavioral Sciences*, *7*, 130-138. doi:10.1016/j.sbspro.2010.10.019

Nordin, N., Hamzah, M.I., Yunus, M.M. and Embi, M.A. (2010). The mobile learning environment for the in-service school administrators. *Procedia – Social and Behavioral Sciences, 7*, 671-679. doi:10.1016/j.sbspro.2010.10.091

Ortiz, T. (2009). *Neurociencia y educación*. Madrid: Alianza Editorial.

Passey, D., Rogers, C., Machell, J. and McHugh, G. (2004). *The Motivational effect of ICT on pupils*. England: University of Lancaster.

Portellano, J.A., Mateos, R. and Martínez, R. (2012). *Cuestionario de Madurez Neuropsicológica Escolar: CUMANES.* Madrid: Tea ediciones.

Portellano, Mateos, Martínez, R., Tapia, A. and Granados, M. J. (2000). *Cumanin. Cuestionario de Madurez Neuropsicológica Infantil.* TEA Ediciones. Madrid.

Prato, A. and Mendoza, M. (2006). Opinión, conocimiento y uso de portales web para la enseñanza del inglés como lengua extranjera. *Revista Venezolana de Información, tecnología y Conocimiento*, *1*, 49-61.

Rabah, J. (2015). Benefits and challenges of Information and Communication Technologies (ICT) integration in Québec English schools. *TOJET: The Turkish Online Journal of Educational Technology, 14*(2), 24-31.

Robinson, P. (2003). Attention and memory during SLA. En C, Doughty. and M, Long (Ed.), *The handbook of second language acquisition* (631-678). Malden, MA: Blackwell. doi:10.1002/9780470756492.ch19

Røkenes, F.M. and Krumsvik, R.J. (2016). Prepared to teach ESL with ICT? A study of digital competence in Norwegian teacher education. *Computers & Education*, *97*, 1-20. doi:10.1016/j.compedu.2016.02.014

Salehi, H. and Salehi, Z. (2012). Integration of ICT in language teaching: Challenges and barriers. *International Proceedings of Economics Development and Research, 27*, 215-219.

Santa-Cruz, C. and Rosas, R. (2017). Mapping of Executive Functions. *Estudios de Psicología, 38*(2), 284-310. doi:10.1080/02109395.2017.1311459

Sekharan, G.K., Setia, R., Mohamad, R., Abdul, Z.B., Luqman, A., Vadeveloo, T. and Ngah, H. C. (2014). Attitude, parental encouragement and perception of the importance of english in english language learning. *Asian Social Science, 10*(3). doi:10.5539/ass.v10n3p1

Shamsudin, A. (2009). *Teaching Effectiveness and Course Content Suitability- A Survey among KPLI English Language Trainees at The Kuala Terengganu*. (Masters thesis). Universiti Teknologi, MARA.

Silviyanti, T. M. (2014). Looking into EFL students' perceptions in listening by using English movie videos on YouTube. *Studies in English Language and Education, 1*(1), 45-63.

Silviyanti, T. M., and Yusuf, Y. Q. (2015). EFL teachers' perceptions on using ICT in their teaching: To use or to reject?. *Teaching English with Technology, 15*(4), 29-43.

Thurstone, L.L. and Yela, M. (2012). *CARAS-R. Test de percepción de diferencias.* Madrid: Tea ediciones.

Tüzün, H., Yılmaz-Soylu, M., Karakuş, T., İnal, Y. and Kızılkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52*(1), 68-77. doi:10.1016/j.compedu.2008.06.008

Vassilopoulou, A., and Mavrikaki, E. (2016). Can ICT in biology courses improve AD/HD students' achievement?. *Improving Schools, 19*(3), 246-257.

Yunus, M.M., Chua, P.L., Maimun, A.L. and Rizauddin, R. (2010). Evaluation of ICT usage for general or English learning purposes. *WSEAS Transactions on Information Science and Applications*, 205-211.

Yunus, M.M., Nordin, N., Salehi, H., Embi, M.A. and Salehi, Z. (2013). The use of information and communication technology (ICT) in teaching ESL writing skills. *English Language Teaching, 6*(7), 1-8. doi:10.5539/elt.v6n7p1

Yunus, M.M., Nordin, N., Salehi, H., Embi, M.A. and Salehi, Z. (2014). Future of ICT as a pedagogical tool in ESL teaching and learning. *Research Journal of Applied Sciences, Engineering and Technology, 7*(4), 764-770.

Yunus, M.M., Salehi, H. and Chenzi, C. (2012). Integrating social networking tools into ESL writing classroom: Strengths and weaknesses. *English Language Teaching*, *5*(8), 42-48. doi:10.5539/elt.v5n8p42

Miriam Romero López, Montserrat López Fernández & Maria Carmen Pichardo Martínez