e-TEALS no. 5 | 2014

An e-journal of Teacher Education and Applied Language Studies

Spaced Learning: Making Space for Neuroscience in the Classroom

Ana Catarina VAZ
| University of Porto

Abstract | The paper offers an insight into the scientific research on the use of neuroscience in today's educational systems and classrooms. It also presents Spaced Learning as an example of practical teaching techniques which apply neuroscience in the classroom. A brief account of the potential relevance of neuroscience in education looks at how neuroscience and education are exploring the potential for scalable solutions, such as Teensleep and Spaced Learning. A closer examination of two different experiments in England and Portugal demonstrates how Spaced Learning has been successfully deployed and raised achievement. Finally, it considers making *space* for neuroscience in the classroom, and aims to explain how the classroom should be prepared for a neuroscientific approach.

Key words | cognitive neuroscience, classroom experiment, spaced learning, attention, ADHD, mind training, synapse,

Citation: Ana Catarina Vaz, "Spaced Learning: Making Space for Neuroscience in the Classroom." *e-TEALS: An e-journal of Teacher Education and Applied Language Studies* 5 (2014): 49-64. ISSN 1647-712X

Cognitive neuroscience – with its concern about perception, action, memory, language and selective attention – will increasingly come to represent the central focus of all neurosciences in the 21st century.

Eric Kandel

Slowly but surely, neuroscience has lately imposed itself in the most significant fields of study, namely in educational research studies and showing its importance in terms of more accurate and effective results regarding students' performance. For the first time ever, The Wellcome Trust and the Education Endowment Foundation will trial neuroscience discoveries in real schools marking thus the beginning of a new era for both education and neuroscience (cf. Philippou). However, preparing the formal classroom for neuroscience should be seen not only as a major investment for a successful report and data collection, but also as a crucial element for a rewarding outcome.

I. Cognitive Neuroscience

It is not by chance that the field of study which focuses on perception, action, memory, language and selective attention, known as neuroscience (neuroscience is the study of the brain and its processes, and these can impact directly on learning) has caught the attention of researchers in the last few years. In an ever growing, technologically dependent society, it is imperative that both educators and educational systems move forward towards an educational system that enhances and promotes not only interdependent and multidisciplinary thinking but also the accurate use of contents and selective attention. With all the resources and memory storage devices available nowadays, it does not seem productive, nor effective, to expect from students few basic facts learnt by heart.

> We spend millions of dollars and years of children's lifetimes teaching them to do sums as well as a $5 calculator . . . , children spend thousands of hours learning basic exact calculations, making those children the most expensive and least reliable pocket calculators on earth. (Kelley, *Making Minds* 146)

This round assertion challenges, firstly, the categorisation of all learning contents. Should we expect learners to operate as readily and skilfully as any electronic device, or should we, on the other hand, train their selective attention and help to fully develop their perception, action, memory and language skills? If we take into account the fact that Kelley, one of the leading educators in the UK, has defined learning as "the development of adaptive skills" (157), then the role of educational systems should be to select more accurately the most pertinent contents to be taught, namely those with the most explanatory potential and practical procedural skills. This is also where selective attention and memory should soon start to converge; inciting innovative neural systems in the brain and fully understand their contribution to a renewed and more powerful educational system.

II. Overview

Even though several aspects of formal learning and understanding may still not be fully understood and explained by neuroscience, many educators have experimented to improve learning. Some of these educators, though little known, made very perceptive analyses of the learning process. For example, Aiken, an American pedagogue, first published the work *Methods of Mind-Training, Concentrated Attention and Memory* in 1895, in which she explained that voluntary attention was an acquired skill or mental behaviour usually attained through habit and, in a more permanent state, aided by external support (Aiken 23). In spite of having her findings only empirically proven, she suggested three essential stages for attaining voluntary attention: 1) positive emotions and rewards; 2) emulation, ambition, practice (artificial attention); and 3) the habit of organizing past contents for more efficient and lasting learning (80-81).

In her work, Aiken also developed the idea that attention should be trained every day for at least 20 minutes. This would then result in better comprehension, greater satisfaction and less study hours for students. However, accurate recall, which should lead to an objective reasoning, should not be mistaken with the concept of learning by heart, but rather understood as accurately remembering and using valuable data. A good memory should always enhance attention, and

attention should always be sustained through (un)pleasant or more complex experiences (80). Most of her theories will be proven right almost two centuries later, as we will see later on with spaced learning.

Moreover, the importance of neuroscience (time patterns in long-term memory) and psychology (retrieval practice) shown empirically by Aiken strongly suggest an important use in education of evidence-based time patterns from both research traditions:

> Although the spacing effect in retrieval has been demonstrated in many subjects and educational contexts to be effective, it has rarely been systematically implemented in education (Dempster, 1988; Seabrook et al., 2005). Despite recent careful analysis of the temporal patterns demonstrating effective recall of word pairs and other tasks (Cepeda et al., 2006; Pavlik and Anderson, 2008; Cepeda et al., 2009) and despite specific programmes based on the approach (Carpenter et al., 2009, 2012; Sobel et al., 2011), this remains the case. (Kelley and Whatson 2)

More recently, neuroscience will be put to test in real contexts throughout schools within the UK. The need of a more challenging teaching environment with more satisfying results has led some of the most important entities in education to investigate a variety of ways neuroscience might improve teaching and learning. There are six projects in total, which will benefit from grants of almost £4 million. These series of randomized controlled trials will be conducted by the Wellcome Trust and the Education Endowment Foundation across England and they will test thousands of pupils after the identified a need for stronger evidence about how neuroscience relates to learning in order to support teachers and schools keen to make use of neuroscientific findings in the classroom. In some of the trials non-invasive bio-telemetric devices and brain imaging will be used to provide additional physiological data (cf. Philippou).

The six chosen projects are *Teensleep*, which will assess the impact of later school start times on teenagers' educational achievement; *Learning counterintuitive concepts*, which will test the benefit of suspending pre-existing beliefs when solving mathematical or scientific questions; *Fit to study*, which will look at the effect of medium to high cardiovascular activity on academic

attainment; *Engaging the brain's reward system*, which will examine the effect of uncertain reward on attainment); *GraphoGame Rime*, which will investigate the benefits of phonological awareness through "rhyme analogy", and finally, and perhaps the most complex and challenging, *Spaced learning*, which will check the effectiveness of repetition and spaced learning, a method that delivers a unit of work three times interspersed with different activities.

III. Spaced Learning

Spaced learning was first put into practice in a classroom in 2005 in, England. The project was initially led by Kelley, and the teaching technique developed by Bradley, a Science teacher. The method behind Spaced Learning is based on Fields' findings, published in the article "Making Memories Stick" in the *Scientific American Magazine* three years earlier, in 2005. Fields, an American researcher at *The Douglas Fields Lab at the National Institutes of Health*, US, found out that any content needed repetition and intervals of inactivity between them in order to be successfully stored as long-term memories:

> Both long- and short-term memories arise from the connections between neurons, at points of contact called synapses . . . . When a short-term memory is created, stimulation of the synapse is enough to temporarily "strengthen", or sensitize, it to subsequent signals. For a long-term memory the synapse strengthening becomes permanent. . . . Long-term memory often requires some kind of repetition . . . . If stimulation is applied repeatedly – three times in the reported experiments – the synapse becomes strengthened permanently. . . . each stimulus must be spaced by sufficient intervals of inactivity (10 minutes in our experiments). (76)

Spaced Learning, based on the findings by Fields, is a teaching method that creates neural pathways at the start of a unit of work and revisits them throughout the same lesson or session. "When we hear, see or do something once, it can be stored in our short-term memory. If we hear, see, or do it repeatedly, it can enter our long-term memory" (Bradley and Patton 3-4).

In short, any spaced learning lesson follows the structure of three main inputs separated by two breaks of a different character. In the first input, the teacher presents a variety of key selected contents in no more than 20 minutes. This should be done at a steady and comprehensive speed to stimulate the synaptic pathways. After the first input, students have a break of 10 minutes at least to perform a different task. This task can be of a playful or entertaining tone, such as dribbling, origami folding or singing, for example. The breaks allow the synaptic ways to rest before being strengthened again during the second input. In the second input, students are expected to revisit the contents presented during the first input and to execute basic tasks (e.g. recalling information, filling in the gaps, solving simple exercises). After the second input comes another pause in order to let the synaptic ways rest once more before being revisited again in the third input. The last and final input, or output, encourages the students to practice fully the contents learnt during the session (e.g. oral presentation of contents, solving more complex tasks) and detect eventual failures in the learning process.

In the first spaced learning experience inside a real classroom, which was led in England, three different groups were used. The total population of 55 students (between 15 and 16 years old) was divided by: experimental group, with whom spaced learning was used for 24 minutes; control group, which learnt the contents for 60 minutes without spaced learning; and a mixed group, with whom both approaches were used for also 60 minutes (24 minutes as in the experimental group; 36 minutes conventional social-based methods) (Kelley, *Making Minds* 154).

In spite of the fact that the final results (Academic Potencial Yellis)[1] were very similar (both experimental and mixed group reached a 4.9 grade and the control group 5.0), the learning efficiency (learning per 60 minutes as measured by the test)[2] was over twice as much in the experimental group when comparing with both the control and mixed groups (173 in the experimental group and 61.1 and 75.2 in control and mixed group, correspondingly), which may represent a substantial time saving inside the classroom, especially if we take into account the usefulness of the breaks for developing other skills (Vaz, *O Spaced Learning Enquanto Abordagem Pedagógica* 80-2, 111-12).

Ermesinde experiment

On a later experiment in Ermesinde, Portugal, with secondary school students, spaced learning was used to teach modern foreign languages.

The first lesson was taught to a 10th form group of nine students (German as a foreign language: A1 level) in a 90-minute session. The theme selected was "Wohnen" (inhabiting), following the national syllabus (cf. Lapa, Mota, and Vilela). Students were already familiar with the different rooms and house types from previous lessons, but all furniture related vocabulary was unknown (cf. Vaz, "Spaced Learning").

At the end of the lesson the experimental group was able to write an average of 54.2 correct words (cf. Table 1). The highest number was 76 words and the lowest 40. Four weeks later the same group of students wrote an average of 38.2 correct words, only 16 less than a month before.

The same final task was conducted in a control group, made of sixteen secondary school students learning German at a higher level (A2), under the exact same conditions (e.g. time limit 20') but without any previous spaced learning lesson. The average number of correct words written went down to 21.6 correct words with values ranging from 10 to 44.

	Average number of correct words written in 20'
Experimental group (A1 level)	**54.2** (min 40 – max 76) → *at the end of the SL lesson* **38.2** (min 25 – max 66) → *four weeks later*
Control group (A2 level)	**21.6** (min 10 – max 44)

Table 1. *Average number of correct words written in 20'* (Vaz, "Spaced Learning in the MFL Classroom" 41)

What is more, two weeks after the original spaced learning lesson, students from the experimental group were able to identify and recall all the requested words (pieces of furniture) at a written examination, achieving an outstanding 100% efficiency at the vocabulary task. In the writing task

of the same examination, students got an average of 89%, being highest and lowest scores 100% and 82%, correspondingly. No dictionaries were used at any stage.

There seems to be great potential lying behind spaced learning, especially if we take into account the evidence from students, teacher, observers and test scores. In order to grade some opinions from students and teachers involved, we used a scale of 1 to 5, where 1 stood for *I totally agree* and 5 for *I totally disagree*.

In the questionnaire answered individually by the students of the experimental group, 88.9% of them said that they were in total agreement (1) with the fact that spaced learning helped their learning process after only one lesson. 11.1% of the students agreed only (2) with this statement (Vaz, "Spaced Learning in the MFL Classroom" 74).

When rating the lesson as a whole, 100% of the students rated the spaced learning session as *more interesting and productive than a regular lesson*. The same percentage agreed totally (1) that they enjoyed learning the lesson contents through spaced learning.

Both observers were also in total agreement (1) that spaced learning was important for students' acquisition (namely the use of different colours and highlighted words) and that both pauses were interesting for students without interfering with the upcoming input stages.

At the end of the fifth spaced learning lesson, both the observer and students (100%) agreed totally (1) on the importance of the breaks for a more efficient learning (Vaz, *O Spaced Learning Enquanto Abordagem Pedagógica* 110).

In terms of assessing attention needs, students from the experimental group were also analysed through an ADHD (*attention deficit hyperactivity disorder*) table, specifically designed to detect and label any eventual lack of attention before, during and after spaced learning. During this particular 90-minute lesson, there were no visible cases of difficulties in *sustaining attention and following instructions* or *concluding tasks,* which had been detected in previous regular lessons. On the other hand, there were occurrences of *abrupt answers*, which means students formulated their answers before they heard the whole question(s) at six different times. At the end of the first lesson there were 12 ADHD occurrences and five sessions later only 3. This means

students were four times more engaged and focusing on their tasks after being prepared to do so (through spaced learning training) (Vaz, "O Spaced Learning" 34, 47).

It is also interesting to mention that before any spaced learning lesson 21 ADHD occurrences were registered and that in a regular lesson (after spaced learning intervention) only 10 were measured in the same experimental group. The effect of spaced learning could be seen even when it was not being used directly. In the control group, in the same period of time, and without any intervention the ADHD occurrences went from 37 to 60 (Vaz, "O Spaced Learning" 47).

Regarding test scores, students from the experimental group went from 74.5% in the first term (without spaced learning) to 77% overall in just five sessions. It is important to note though that these tests covered subjects taught without spaced learning as well, so it might account for other relevant purposes: spaced learning as a self-disciplinary tool (47). In one of the tests all students got 100% in the vocabulary exercise (first spaced learning lesson).

It seemed nonetheless relevant to explore other significant issues. In addition to the improvement in self-discipline, there was an improvement in working habits and motivation, for example. With spaced learning, students had the chance to receive a quantitative classification to check their acquisition at the end of each lesson, which was done by the students themselves, collaboratively (working in pairs or small groups) or by the teacher, and it was used as an assessment tool.

The Spaced Learning developments at Monkseaton proved to constantly increase the rapidity, accuracy and educational impact, that is, good high-stakes test scores. In addition to it, the Ermesinde experiment demonstrated that a series of spaced learning lessons could help less able students outperform more able students, which hardly happens in Education. Both of these suggest spaced learning has huge and unprecedented potential.

Taking this evidence into account, great efforts have been taken both by public and private organisms in the UK and worldwide to prepare and train educators for the challenges of recent findings about spaced learning and further projects. Osiris Educational, for example, one of the leading independent training providers for teachers in the UK has presented different spaced

learning training sessions on Science, Modern Foreign Languages and the method itself. In one of the courses, teachers were expected, among other things, to acquire useful knowledge on how to prepare themselves and their classroom for spaced learning; on how to make *space* for it.

IV. Spaced Learning: Making *Space* for Neuroscience in the Classroom

Before initiating any major project or change in the teaching approach or classroom dynamics, whether neuroscientific related or not, both educators and students should be fully aware of the implications that those choices may hold.

In the case of spaced learning, for example, teachers of a specific subject and target group, should list the reasons why this specific group may be in need of an intervention of this kind. Therefore, one of the first questions they should ask is *why* the students might need spaced learning. For example, it has been proven that this method enhances low and/or heterogeneous results within a group. In other words, weaker students tend to participate more (quantitatively and qualitatively), getting better results (especially) in the last task, which leads to a lower heterogeneity within the group: from 4.4 to 3.5 standard deviation (the amount of variation from the average results) after only five spaced learning sessions (47).

Also, due to its mutually engaging aspect, namely during the breaks which are usually spent in team work/games, spaced learning may encourage students to work towards a more collaborative environment as well.

The attention deficit disorder, whether with or without hyperactivity, (AD[H]D) has been classified as one of the most common neural conditions in childhood, with a prevalence of 3% in girls and 8% in boys, and also teenage years (Skokauskasa et al. 291). AD(H)D is the term used to indicate that an individual has a significant problem maintaining attention during a specific expected task (cf. Greenberg). As difficult as it is to diagnose and control this disorder, students with a higher number of inattentive reactions have shown a significant decrease in disruptive occurrences after only five spaced learning sessions (from 12 to 3 occurrences) (Vaz, “O Spaced Learning” 34, 43). Their performance after kinaesthetic activities during the pauses also produced

better results in the upcoming input/outcome (Vaz, *O Spaced Learning Enquanto Abordagem Pedagógica* 81). Both these conclusions come to show that spaced learning may help to control and discipline sustained attention, the ability to renew attention which allows people to "pay attention" to things that last longer than a few minutes.

Spaced learning also allows teachers to focus on a specific chosen skill or skills. This is especially important in the foreign language learning context. During the experiment in Portugal, for example, in which selected groups of students learnt a foreign language through spaced learning, a main skill was always in focus and allowed, therefore, students to acknowledge and overcome specific problems within that skill.

The students take took part in the experiment in Portugal acknowledged vocabulary acquisition and grammar as the most suitable and efficient for spaced learning during the experiment (112). Different students and different learning (dis)abilities may lead to different conclusions.

Since spaced learning follows the same basic structure and the activities chosen for the pauses are usually based on either ready-made materials or games (e.g. play-dough moulding, Simon says) that need less preparation, it can be concluded that the method may be useful when there is a lack of time to teach the book and to prepare materials, as it acts as a mean of compressing information and boost imagination. Furthermore, since a single lesson may comprehend an extensive amount of contents, it may be also suggested that spaced learning is used as a revision tool (60).

Other aspects such as boredom or general lack of interest may also be valid reasons for opting for spaced learning. These two conditions were diagnosed during a pre-spaced learning phase and they were both overcame after its implementation in the classroom; the method produced a very positive reaction; becoming itself a motivation for the lesson (34).

In short, it may be said that spaced learning, when thoroughly prepared, may 1) be easily adapted to any skill/subject; 2) improve learning and studying methods; 3) entertain students during the pauses, thus motivating them for the upcoming input/output phases and allowing them

to develop new skills (e.g. juggling); 4) enhance collaborative learning; 5) facilitate the assessment of quantitative and qualitative output; 6) become a motivational and disciplinary tool.

On the other hand, a few weaker points should be taken into account before deciding for a spaced learning approach. Firstly, it is imperative that the pre-established times are respected, so students (and educators) who are not used to firm self-discipline should be the object of a more disciplined attitude before engaging in the method. Secondly, since there might be a strong teacher's presence throughout the whole session, teachers should opt for a monitoring attitude rather than risking to lose the students' autonomy. Finally, and acutely related to this last issue, the prevalence of the *teacher talking time* (TTT), the time that teachers spend talking in class, should be, at an early stage, regulated and previously drilled outside the teaching context so that it does not nullify the students' performance and levels of attention.

Another crucial aspect that should be taken into account before opting for a spaced learning approach, and perhaps the feature which makes every spaced learning trial unique, is the type of spaced learning which each group or individual demands. In other terms, it has been proved fundamental to get to know the specificity of a teaching target before effectively choose the method through which students will learn (Alberts and Wulf 55).

Some suggested approaches to do this may include preference and/or personality tests of different sorts (e.g. VARK test), previously observed needs, learners' suggestions and requests (e.g. the pause as reward: play a favourite game during the break). Whichever approach is taken, pleasing everyone, even if at different times, will be a sure way to bring the group together and implement democratic teaching and learning styles.

Despite the specific reason behind the use of spaced learning, least favourite activities, weaker skills and cooperation enhancement can be overcome even when the main issues are different (e.g. ADHD) (Vaz, "Spaced Learning in the MFL Classroom" 36).

Conclusion

It seems significant that teachers anticipate the impact, and even potential interference, of spaced learning, or any other approach, on the pre-established teaching aims. So the answer to the question on whether spaced learning may interfere with set-up teaching aims is *yes*, it can, but only if there is no preparation. This means that teachers should be able to adapt spaced learning to the syllabus, classroom environment and their own teaching style and aims – and never the other way round.

In summary, before setting up a lesson scheme or any short/medium/long-term plan for implementing spaced learning in the classroom, it is necessary to first make *space* for four essential questions: 1) Why use spaced learning?; 2) What is the target group type of spaced learning?; 3) What are the teaching aims?; and finally 4) How will spaced learning interfere with pre-established contexts, if at all? Keeping a record of all events (e.g. teaching log, output results) as well as taking into account previous feedback from students will surely lead, as it has already done, to outstanding results both in educational and neuroscientific contexts.

Further reading

Aiken, Catharine. *Methods of Mind-training: Concentrated Attention and Memory*. New York: Read Books, 2009.

Fields, R. Douglas. "Making Memories Stick." *Scientific American* 292.2 (2005): 75-81.

Kelley, Paul. *Making Minds: What's Wrong with Education, and What Should We Do about It?* London: Routledge, 2008.

Vaz, Ana. *O Spaced Learning Enquanto Abordagem Pedagógica Potenciadora da Atenção, Retenção e Memorização Exata nas Aulas de Língua Estrangeira do Ensino Secundário*. Diss. [Master's Degree in Education]. Universidade do Porto, 2013.

Further information

- spacedlearningteam@gmail.com
- www.facebook.com/spaced.learning
- http://spacedlearning.wix.com/spacedlearning
- http://makingminds.net/

Notes

[1] The UK's best measure of learning potential: higher scores being better (Kelley 154).

[2] A form of examination introduced in 2006, reducing the chance of prior learning in the groups (Kelley, *Making Minds* 154).

Works Cited

Aiken, Catharine. *Methods of Mind-training: Concentrated Attention and Memory*. New York: Read Books, 2009 [1895].

Alberts, Bruce, and William Wulf. *Science Teaching Reconsidered: A Handbook*. Washington DC: National Academy, 1997.

Bradley, Angela, and Alec Patton. "Spaced Learning: Making Memories Stick." *Innovation Unit*. 2008. Web. 19 Feb. 2014. <http://www.innovationunit.org/sites/default/files/Spaced_Learning-downloadable_1.pdf>.

Fields, R. Douglas. "Making Memories Stick." *Scientific American* 292.2 (2005): 75-81.

Greenberg, Lawrence M. "Attention Deficit Disorders and the Test of Variables of Attention (T.O.V.A.®)." *About Attention*. The TOVA Company. Web. 19 Feb. 2014. <http://www.tovatest.com/adhd/#index8h2>.

Kelley, Paul, and Terry Whatson. "Making Long-term Memories in Minutes: A Spaced Learning Pattern from Memory Research in Education." *Frontiers*. 25 Sept. 2013. Web. 19 Feb. 2014. <http://journal.frontiersin.org/article/10.3389/fnhum.2013.00589/full#h4>.

Kelley, Paul. *Making Minds: What's Wrong with Education, and What Should We Do about It?* London: Routledge, 2008.

- - - . "Neuroscience In Education Trials Announced." *Making Minds*. 9 Oct. 2014. Web. 19 Nov. 2014. <http://makingminds.net/2014/10/neuroscience-education-trials-announced/>.

Lapa, Carlos, Lídia Silva Mota, and Margarida Vilela. "Programa de Alemão 10.º, 11.º e 12.º Anos." *Ministério Da Educação*. Apr. 2001. Web. 19 Feb. 2014. <www.dgidc.min-edu.pt/data/ensinosecundario/Programas/alemao_iniciacao_10_11_12_anos.pdf>.

Philippou, Emily. "New Research to Investigate If Neuroscience Can Improve Teaching and Learning in Schools." *Wellcome Trust*. 9 Oct. 2014. Web. 19 Nov. 2014. <http://www.wellcome.ac.uk/News/Media-office/Press-releases/2014/WTP057594.htm>.

Reilly, Randall C., and Yuko Munakata. *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain*. Cambridge, Mass.: MIT, 2000.

Skokauskasa, Norbert, Fiona McNicholas, Tawfik Masaudc, and Thomas Frodld. "Complementary Medicine for Children and Young People Who Have Attention Deficit Hyperactivity Disorder." *Current Opinion in Psychiatry* 24 (2011): 291–300.

Vaz, Ana. "Spaced Learning." *Infoappa*. InfoAppa, Dec. 2012. Web. 19 Feb. 2014. <http://www.appalemao.pt/downloads/revista45.pdf>.

- - -. "O Spaced Learning Enquanto Abordagem Pedagógica Potenciadora da Atenção, Retenção e Memorização Exata nas Aulas de LE do Ensino Secundário." Presentation. Universidade do Porto. 24 July 2013a. Viva Voce.

- - -. "Spaced Learning in the MFL Classroom: Does Your Classroom Speak SL?." Training Course. Osiris Educational, London. 26 June 2013b. Lecture.

- - -. *O Spaced Learning Enquanto Abordagem Pedagógica Potenciadora da Atenção, Retenção e Memorização Exata nas Aulas De Língua Estrangeira do Ensino Secundário.* Diss. [Master's Degree in Education]. Universidade do Porto, 2013c. Print.