DO WE LEARN BY HEART?

DAVE BÉLANGER*
Teacher
Cégep Lévis Lauzon

We usually remember pretty well the first time we fell in love or our first heartbreak. However, it is not quite as easy to remember where we parked the car last month.

What distinguishes a lasting memory from one that fades away? In recent years, a certain number of research studies, as much in Psychology as in Neuroscience, tend to demonstrate that emotions are at the heart of the processes of learning and memorization. How do emotions influence memory? Do we need to feel in order to learn?

From a psychological perspective, eliciting an emotion makes it possible to direct attention, something that is necessary for learning and memorization (Green, 1999).

In class, students seem to appreciate teachers who stimulate their affective sides. In fact, two of the main qualities that characterize good teachers, as identified by students, are the enthusiasm they emit and their senses of humour (Saint-Onge, 1987). These same qualities emerge from an interview, conducted by Savoie-Zacj in 1994, with 15 students who were considering dropping out of school (see Viau, 2005). And yet, enthusiasm and humour have a lot more to do with emotions than with course content... So, can emotional elements directly influence the construction of memories?

According to Favre, a teacher-researcher in Education at l'*Université de Montpellier*, "a subject's emotional state interferes constantly with the processing of information. There is therefore no cognitive functioning that is independent of emotional functioning" (Favre, 2006). Thus, still according to Favre, we must think of learning as a process that is not only cognitive but also emotional.

Unfortunately this reality is often underestimated. Take for example, Viau who is recognized for his work on motivation in the school context and who writes that the influence of emotions is secondary in the process of motivation (Viau, 1994, p.102). Another example, Piaget and Gardner who, for legitimate reasons of methodology simplification, disassociated cognitive and affective (emotional) processes (Favre, 2006). Given the major influence of these two researchers in the world of pedagogy, some authors believe that his disassociation has helped to amplify the tendency to separate body (emotions) and mind (cognition) during learning (ibid.). The evolution of scientific knowledge and its diffusion could, however, give emotions their rightful place in the processes of learning and memorization. Here are, briefly, some of the scientific findings that may prove to be useful to teachers.

FROM PSYCHOLOGY TO NEURONS...

The brain is the seat of emotions and of learning. It is made up of billions of cells called **neurons** that form vast communication networks. These networks make it possible, for example, to associate different stimuli (such as the scent of a flower and the sight of this flower) or to store certain events in memory. Within these networks, the neurons communicate amongst themselves by generating electrical impulses. However, each neuron remains completely isolated from its neighbours. So, then, how do they manage to communicate with each other? By using one type of key known as a **neurotransmitter.**

When a neuron wants to send a message to its neighbour, it releases a neurotransmitter into the space between them. This space is referred to as a **synaptic cleft**. When the neurotransmitter reaches the neighbouring neuron, it acts like a key that fits into a lock: it unlocks a door. When the door is unlocked, the second neuron is informed that it has just received a message from its neighbour and one that it can, in turn, transmit.

It is however important to clarify that the second neuron does not automatically transmit a message when it receives neurotransmitters from a neighbour. Before that, the first neuron must release enough neurotransmitters. In other words, in order for the second neuron to react, the first neuron must be sufficiently insistent. Next, the second neuron must expose a sufficient number of "locks" on its surface. These "locks" called **AMPA**[1], can be compared to ears that make it possible to hear the messages from neighbouring neurons. The more ears that are exposed, the more the message is likely to be heard, and, in the end, transmitted.

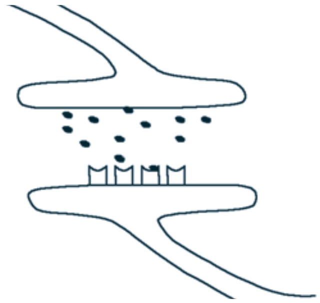
* The author wishes to thank Luc Desautels, Ph.D. for his valuable comments and his judicious advice.

[1] AMPA: Alpha-amino-3-hydroxy-5methyl-4isoxazole proprionic acid

Figure 1

In this figure, the neuron on top releases its neurotransmitter (circle) in the space between the two neurons (synaptic cleft).

This neurotransmitter places itself in its AMPA “lock” (little white boxes on the surface of the bottom neuron).



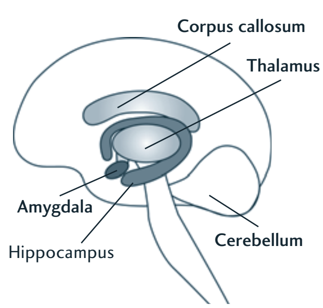
We know today that when we memorize something, a specific network of neurons develops in a variety of brain structures (Laroche, 2001). When we recall this memory, all that is necessary is to activate the corresponding network. The stronger the network, that is, when the neurons in the network release a lot of neurotransmitters and expose a large number of AMPA locks, the more durable will be the corresponding memory (ibid.). The more frequently a network is solicited, that is, the more often it is activated, the more solidified it becomes. Put another way, the more frequently a memory is recalled, the more it consolidates. This, by the way, is what explains why some people who suffer from Alzheimer’s disease remember very old events but forget the most recent ones...

FROM NEURONS TO MEMORY...

Memory is not located in a specific place in the brain. However, it is constructed mainly in a structure situated in the centre of the brain called the **hippocampus.** It is inside this cerebral structure that the networks of neurons associated with memory develop – especially long-term memory.

Figure 2

The hippocampus is a structure located in the middle of the brain. It is involved in the process of long-term memorization. It is interesting to note the proximity of the hippocampus and the amygdala, a structure involved with emotions.

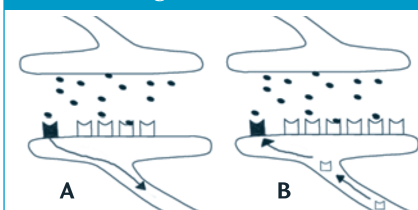


In 1973, a team of researchers discovered how the networks of neurons in the hippocampus manage to consolidate; that is, how they release more neurotransmitters and expose more locks. By applying a weak, very brief electrical charge to sections of the hippocampus, the researchers observed that the stimulated circuits became more sensitive (easier to activate) and that this sensitivity lasted several weeks, even months! They named this phenomenon **long-term potentiation** or **LTP** (ibid.).

Today we have a better understanding of how this long-term potentiation functions. The weak electrical charge applied causes the neurons to release many more neurotransmitters than normal in the synaptic cleft. The latter attach themselves, as they normally do, to the AMPA locks of the second neuron. However, the excess neurotransmitters released manage to unlock a second type of lock called **NMDA**[2].

NMDA locks are much more difficult to unlock – hence the necessity for a larger number of neurotransmitters. However, when they are unlocked, they send a signal to the neuron to make more AMPA locks and to expose them in the synaptic cleft (Hu, Real, Takamiya, Kang, Ledoux, Huganir and Malinow, 2007). In other words, when they are unlocked, the NMDA locks order the neuron to produce more ears to hear its neighbours’ signals even better. The result is a consolidation of the network.

Figure 3 — LTP



In A, a large number of released neurotransmitters manage to unlock the type of lock called NMDA (little black box). Once opened, the NMDA lock transmits a message to the neuron asking for more AMPA type locks (little white boxes) to be made. This request is represented here by an arrow.

In B, the new AMPA locks have been made and transmitted towards the synaptic cleft, where they will finally be exposed. The result is a larger number of AMPA locks in the synaptic cleft, thereby consolidating the communication between the two neurons involved.

[2] NMDA: *N*-Methyl-D-aspartate

FROM EMOTION TO MEMORY...

These weak electrical impulses, applied in order to generate LTP and the consoli-dation of a network of neurons, also occur naturally. The neurons themselves are capable of producing them under certain conditions. Furthermore, it seems that a region of the brain located very close to the hippocampus facilitates the release of LTP in the hippocampus. We refer here to the **amygdala.** This structure plays a major and pivotal role in the release of emotions (Abe, 2001).

> *[...] the impulses associated with emotions could modulate the durability of neuronal networks linked to memories.*

In addition, the amygdala maintains very close ties to the hippocampus: many neurons in the amygdala communicate with the hippocampus and vice versa. Moreover, we can observe the close relationship between these two structures in Figure 2.

Experiments on animals with lesions that had been caused in the amygdala region demonstrated that their hippocampus had much more trouble generating LTP and this translated into greater difficulty with learning and memorization. For example, the animals had much more difficulty finding their way through a maze than those in the control group (Abe, 2001). Another experiment showed that stimulating certain areas of the amygdala – which, as we mentioned earlier, is involved in triggering emotions – leads certain neurons in the hippocampus to generate LTP more easily, a necessity in the consolidation of networks (Abe, 2001). These experiments strongly suggest that impulses emanating from the amygdala can modulate the solidity of the neuronal networks of the hippocampus.

In other words, impulses associated with emotions could modulate the durability of neuronal networks linked to memory.

A study conducted by Meyer and Turner in 2006 would suggest that learning requires positive emotional experiences because the process involves self-esteem. Viau (1994) had already mentioned the importance of "one's own perception of being able to succeed in a task" as a source of motivation and success. In light of the relationship that exists between the amydala and the hippocampus, it is tempting to conclude that positive emotions act more directly on learning and memorization than we used to believe...

FROM MEMORY TO THE CLASSROOM...

The most recent publications in the world of pedagogy very closely espouse the student-centred paradigm. For example, many of them suggest an active role for students in order to favour the construction of knowledge. However, few of these publications have dealt with the neurobiological processes that underlie all learning. The latest developments in Neuroscience suggest that when information is emotionally charged, it is more easily stored in memory. The affective component in class could therefore have implications for learning by acting not only on self-esteem and perception of one's ability to succeed, but more directly on strengthening the memorization process. We could then think that, together with recent knowledge developed in the context of student-centred learning, the information-emotion connection could further improve students' retention of knowledge.

Since the appearance of this paradigm, teachers have now had added to their function of being masters of their disciplines, that of being organizers of learning situations. In view of the new scientific breakthroughs discussed here, we could think of adding a third function: teachers could offer knowledge with an emotional tone. By doing so, they would make it easier for students to convert information into knowledge and then into memory. Who knows? The inclusion of an emotional charge during the construction of knowledge might allow students to remember as easily as they can recall the first time they fell in love...

BIBLIOGRAPHY

ABE, K., «Modulation of Hippocampal Long-term Potentiation by the Amygdale: a Synaptic Mechanism Linking Emotion and Memory», *Japanese journal of pharmacology*, vol. 86, 2001, p. 18-22.

FAVRE, D., «Émotion et cognition : un couple inséparable», *Cahiers pédagogiques*, n° 448, 2006.

GREEN, F. E., «Brain and Learning Research: Implications for Meeting the Needs of Diverse Learners», *Education*, vol. 119, n° 4, 1999, p. 682-688.

HU H., E. REAL, K. TAKAMIYA, M.-G. KANG, J. LEDOUX, R. L. HUGANIR et R. MALINOW, «Emotion Enhances Learning via Norepinephrine Regulation of AMPA-Receptor Trafficking», *Cell*, vol. 131, 2007, p. 160-173.

LAROCHE, S., «Les mécanismes de la mémoire», *Pour la Science*, édition française de *Scientific american*, avril-juillet, 2001, p. 52-59.

MEYER, D. K. et J. C. TURNER, «Re-conceptualizing Emotion and Motivation to Learn in Classroom Contexts», *Education and psychological review*, vol. 18, 2006, P. 377-390.

SAINT-ONGE, M., «Les matières scolaires peuvent-elles intéresser les élèves ?», *Pédagogie collégiale*, vol. 1, nº 1, 1987, p. 16-18.

VIAU, R., «Les facteurs externes qui influent sur la dynamique motivationnelle de l'élève», tiré d'un document PERFORMA (2005) disponible à l'intérieur du cours *PED853* offert à l'été 2008.

VIAU, R., *La motivation en contexte scolaire*, Saint-Laurent, Édition du Renouveau Pédagogique, 1994.

A Biology teacher at *Cégep Lévis Lauzon*, Dave BÉLANGER holds a master's degree in Neurobiological Science from *l'Université de Montréal*. He has been engaged in the field of biomedical research for nearly 10 years, working especially on neurological damage associated with the AIDS virus. He is presently pursuing a master's degree in Education on the subject of the involvement of emotions in the learning process.

davebelanger@videotron.ca