FAB 9 Study Sheet #1 – Learning

From Curtis Kelly's chapter in *Innovations in Teacher Training*, Springer Press (in press)
More Study Sheets at: http://www.tinyurl.com/neuroELT

Topic 1: Learning, memory, and attention (This one is a bit hard)

As teachers, we are in the learning business. Learning, in simple terms, means memory formation[1]. Memory formation means neurons connecting to each other through synapses, or the strengthening or pruning of those connections that already exist. Strengthening involves increasing the number of synapses between two neurons, shedding others, adding more receptors to synapses, or myelinating long axons, which can increase firing speed up to a hundred times (Hartline and Colman, 2007). It is misleading to think of the brain as being like a computer, and it is misleading to think of neurons as being simple electric circuits. Each of the thousands of synapses on a neuron has its own complex mix of hundreds of types of receptors, which are also heavily influenced by the cocktail of neurotransmitters they are bathed in. It is more appropriate to think of each single neuron as a computer.

Likewise, it is wrong to think of the brain as being hardwired. We are born with almost all our neurons already formed, but with only 20% of the connections between them in place. Unlike connections in computers, those between neurons are not permanent. Infants, for example, start with everything connected, and up until the age of five shed more connections than they make, in a kind of fine tuning In fact, babies are born as "citizens of the world," with the ability – meaning neural connections – to hear any phoneme in any language (Kuhl, 2004). The neural connections for sounds that are not reinforced by L1 input, such as "L-R" differences for Japanese, are lost.

In fact, the highly plastic nature of the brain is why we can learn so much. Another aspect of learning and plasticity is the fascinating way the brain takes parts that evolved for one purpose and reuses them in others. Whereas we once believed that specific brain areas had specific functions, that notion has been overturned by the massive redeployment (or neural reuse) hypothesis (Anderson, 2010). The brain is adept at cobbling together networks originally developed for one purpose into a variety of coalitions that are used for new purposes (Campbell, 2015b). For example, one small part of the brain, the left inferior parietal sulcus seems to have evolved to manage your fingers. It identifies which finger is touched, but it is also recruited for use in higher level functions involving organization, like figuring out the relative size of numbers.

Language too, uses many parts of the brain that originally evolved for other functions, including the sensory cortices. In fact, that we could take the same sensory systems we use to interpret incoming information and repurpose them to store episodic memory and process language is an amazing achievement. Not so amazing is our inability to talk on the phone and drive safely at the same time; the same areas in the visual cortex required for visual vigilance are decoupled to simulate verbal meaning (Bergen, 2012). Do not read this while driving.

Getting back to memory formation, as a reader you just made thousands of new connections (I hope) reading the paragraph above, but you will not be able to keep them very long.

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1 Memory is a slippery proposition in neuroscience. Does it, as we think of it, even exist? After all, every time you remember something, you change it; reactivating an existing network alters the connections. In fact, all the notions we have about how the mind works are all just one thing, networks activating. According to Spencer Robinson, "learning, cognition, understanding, knowledge and memory are indistinguishable – all simply interchangeable terms for the same process – each thought, idea, feeling, memory, etc., simply a unique pattern of neuronal interconnectivity" (2015, p. 97)

Almost all of what you read might have gone into short-term memory, but only a small part of it, or maybe none at all, will go into long-term memory[2]. You are bound to forget most of this chapter even before you finish it, and you'll forget more each hour afterwards. Some of it might be retained longer, and over the next two weeks, some of it might even be integrated into the rest of what you know, meaning you will probably keep the gist of it for the rest of your life. Something happens to some short-term memories that make them long term, and if we can find out what that is, then we have discovered the holy grail of teaching.

The first step in forming any kind of memory is paying attention. With hundreds of bits of data entering our sensory system at any given moment, we have to filter out the little bit that is important and send it on for further processing. This is handled by the reticular activating system located in the brain stem, but which is also connected to everywhere else. This filter passes on sensory information related to personal relevance, recent executive thinking, and novelty, among other things (Willis, 2007).

The brain's sensitivity to personal relevance is extremely important for teachers, and should be taken advantage more in materials development. Emotion and cognition are the same thing (Pessoa 2013), and all memories have an emotional valence (Montague, 2006). Therefore, all input automatically gets tagged as relevant to us, or not. That determines whether we send it up for further processing and memory or not.

Novelty, something else the brain is particularly sensitive to, is another factor teachers should take advantage of. We evolved a sensitivity to novelty as a way to survive. A mouse coming out of its hole and noticing a subtle change in its surroundings is less likely to be eaten and more likely to find something tasty to eat. Novelty causes dopamine release (Goldberg, 2002), a neurotransmitter associated with deeper learning. Putting learning targets in novel packages, such having students repeat fruit vocabulary and sticking "gorilla" in, leads to greater retention of not just the novel part, but the fruit words as well.

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[2] Disclaimer: As suggested in footnote 3, short-term and long-term memory do not really exist in the brain. These are just notions we have developed to frame long term potentiation.