Creativity in the primary classroom – the biology of learning – brain freeze in a heatwave

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I had an interesting experience on the dance floor recently. I was attending an excellent course where we explored some fundamental concepts that underlie lindy hop dancing. The teachers had clearly thought through the programme as each day involved a lot of revisiting learning along with practice, practice, practice of that and the new ideas that they introduced. Everything was, quite literally drilled into you and I found the message and the method inspiring. However, by the end of the third day, my brain and body ceased conversing and I was literally unable to follow through on any of the dance moves. I felt exhausted on all levels and knew that it was time to stop and regroup. A week later I am still finding my feet, both in my dancing shoes and in my head, and it has caused me to query why this experience occurred.

Hindsight is a marvellous thing and it wasn't hard to spot some key players in the problem.

I started the course at the end of a busy work phase and had already enjoyed long days with late nights volunteering at a church conference at the O2 arena in London the week beforehand. This coincided with the rather intense heatwave that substantially disrupted my sleep that week as well as influence, to some degree, my nights under the duvet during the dance course. I'm not a huge fan of eating when it is hot either but made sure that I drank lots of water. So, I started to dance from a place of tiredness and insufficient calories and continued to add to exhaustion levels without topping up the energy stores. No wonder I crashed and burned! However, it wasn't my body's response that bothered me, more that of my brain. I felt I could no longer access the learning that was there and I found that intriguing. What was going on?

Feed me!

For a small part of the body, the brain has high energy requirements. The brain represents 2% of the total body mass yet requires around 20% of the oxygen and 25% of the glucose consumed by the human body. The brain doesn't store energy reserves and is therefore very dependent on its blood supply for oxygen and glucose. (1). As the brain focuses on a particular task, glucose and oxygen are taken up by the relevant brain cells or neurons (2). So, eating insufficient calories was clearly unhelpful as was the lack of sleep. Sleep loss has the effect of reducing, by around one third, my brain's ability to extract any of the low levels of available glucose (3). So, a bit of a double whammy there then, with a lack of food and sleep literally starving my poor old brain of energy at a point where I was making it work hard.

This is where I found that the 'practice, practice, practice' focus that I liked had its limits. It appears that the longer you focus on a task that demands your attention, the worse you will get at it. It is possible that this 'time on task effect' is limited by the brain's ability to reset and replenish the active neurons involved in the task. This will vary with the person doing the task and the type of concentration levels required for the activity; each person has their own physiological ceiling as to how well they will perform on a particular day on a particular task.(4) . Being tired and hungry don't help. When you add in lack of sleep before an activity, the thalamus and prefrontal cortex can't scan and prioritise incoming information as efficiently so it is harder to work through an attention demanding task. Concentration spans reduce and performance drops (4).

"Please sir, can I have some more?"

The neurons consume 75-80% of the energy needed in the brain with the majority of this used to restore the cell membrane once the synapse has fired or depolarised. This occurs when it is

stimulated by an event or activity and involves some clever stuff with the movement of sodium and potassium ions that allows the cells to engage and then reload (5). These reloading needs take time and resources. The more synaptic engagement in particular areas of the brain over a task, the higher the glucose and oxygen demand in those regions. (6)

A few good nights sleep and some decent food were obviously required but I also have to factor in three further considerations.
As someone with an adult brain who is long way out the other side of 21, my brain's ability to process glucose and oxygen as I focus on tasks is going to be slower than that of a child (7). And, when you're sleep deprived, it's also likely that the body chemistry changes to that of someone much older – we age considerably without our dose of restorative sleep (3). This influences our recovery rates and most probably explains why I'm not quite at 100% yet, a week later. More rest clearly required!
The high temperatures didn't help either; blood supply of all the essentials to the brain decreases when under heat stress. It is harder to focus on hot days (8).

The writing was on the wall and I blame it all on the temporarily imported European heatwave that saw temperatures soar into the 30s. One of our delightful English summers with warm days and cool nights would have been so much better for this ageing dancer!

"More? You want more, boy?"

How does this relate to the primary classroom? Heatwaves in the English climate are few and far between but maintaining healthy levels of sleep and food intake appear to be key. Children, because their brains are developing, need more brain fuel than the adult equivalent (9). This has to include sufficient sources of glucose from a balanced diet that includes carbohydrates (11). And they need sleep too. In school-aged children, total desired sleep time is between 9 and 11 h (10).

On the basis of my own experience, I would suggest that, when diet and sleep are limited, our brains will struggle to keep up. And on those rare hot days? You may find it more cerebrally productive to find ways to chill.

Just saying!

References

(1) Bélanger, M., Allaman, I., and Magistretti, P.J. (2011) Brain Energy Metabolism: Focus on Astrocyte-Neuron Metabolic Cooperation, *Cell Metabolism*, 14 (6), Pp 724-738. https://doi.org/10.1016/j.cmet.2011.08.016. (http://www.sciencedirect.com/science/article/pii/S1550413111004207)

(2) Lundgaard, I.,Baoman, L.,Xie, L., Kang, H., Sanggaard, S., Haswell, J.D.R., Sun, W., Goldman, S., Blekot, S., Nielsen, M., Takano, T., Deane, R. and Nedergaard, M. (2015) Direct neuronal glucose uptake heralds activity-dependent increases in cerebral metabolism. *Nature Communications,* 6 https://doi.org/10.1038/ncomms7807

(3) Medina, J. (2014) *Brain Rules: 12 principles for Surviving and Thriving at Work, Home and School.* 2nd edn. p 145-7. Seattle: Pear Press.

(4) Lim, J., Wu, W., Wang J., Detre, J.A., Dinges, D.F. and Rao, H. (2010) Imaging brain fatigue from sustained mental workload: An ASL perfusion study of the time-on-task effect, *NeuroImage*, 49, Issue 4, Pp 3426-3435, https://doi.org/10.1016/j.neuroimage.2009.11.020. (http://www.sciencedirect.com/science/article/pii/S105381190901204X)

(5) https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/depolarization-hyperpolarization-and-action-potentials

(6) Watts, M. E., Pocock, R., & Claudianos, C. (2018). Brain Energy and Oxygen Metabolism: Emerging Role in Normal Function and Disease. *Frontiers in molecular neuroscience*, *11*, 216. doi:10.3389/fnmol.2018.00216 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6023993/#B61

(7) https://link.springer.com/article/10.1007/s11682-019-00157-w

(8) Bain, A., Nybo, L., Ainslie, P.N. (2015) Cerebral Vascular Control and Metabolism in Heat Stress *Comprehensive Physiology* 5(3):1345-1380 DOI: 10.1002/cphy.c140066

(9) Harris, J.J., Jolivet, R. and Attwell, D. (2012) Synaptic Energy Use and Supply, *Neuron*, Volume 75, Issue 5, Pp 762-777. https://doi.org/10.1016/j.neuron.2012.08.019. (http://www.sciencedirect.com/science/article/pii/S0896627312007568)

(10) Hiscock, H., Davey, M. J. (2018) Sleep disorders in infants and children *Journal of Paediatrics and Child Health Volume* 54, Issue 9 pp 941-944. Doi:10.1111/jpc.12033

(11) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/618167/government_dietary_recommendations.pdf