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Shining a light on new thinking in neuroplasticity: Lessons for the classroom

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Abstract

In simple terms, the extremely complex process called neuroplasticity, refers to the human brain's life long ability to change and adapt in response to the amount and type of stimulation it receives. Like all change, depending on the circumstances, responses can be positive or negative, helpful or unhelpful. Teachers of children with vision impairment and associated disabilities therefore need to be well informed in the current thinking around neuroplasticity and acutely aware of the implications for their teaching. A key principle of neuroplasticity that helps inform pedagogical design is the idea that positive neuroplastic development results from careful management of stimulation, particularly for children with profound multiple disabilities. Stimulatiom that is more multisensory and gratifying naturally has greater potency, although this varies with age and type of disability. This is because the child goes through different neuroplastic stages and prior experience and capability influence the nature and potentiality for future change. Other factors that help reinforce positive change are social interaction, exercise, sleep hygiene and a healthy diet. Another consideration when working with children with profound disabilities is the idea of compensatory neuroplasticity, which occurs when one function is lost or missing and another function is introduced to take its place.

Introduction

Greetings everyone. I hope you've been enjoying the conference. It's hard to believe that we've already reached the final day.

I was delighted when I received the invitation to deliver this keynote for the SPEVI conference. It gives me an opportunity to share with you the work I've been doing in the area of multisensory stimulation and neuroplasticity.

In simple terms, the extremely complex process called neuroplasticity, refers to the human brain's life long ability to change and adapt in response to the amount and type of stimulation it receives.

As many of you already know my research interest has been primarily in the education of children with vision impairment and associated disabilities. I've published three books (Pagliano, 1999, 2001, 2012) on this topic and my talk today comes largely from this material, although there's some new ideas as well. Actually it's been a lot of fun for me preparing this paper and learning new things. I now get to share them with you and see what you think – whether they're useful or not for your teaching. I sincerely hope so.

Two vignettes on listening

I want to start by reading part of an Italian poem "La pioggia nel pineto". The English title is "Rain in the pinewood".

The poem was written in 1902 by Gabriele D'Annunzio. When he wrote it he wanted the Italian words to create musical sound patterns that resemble the falling of raindrops on different vegetation. The English translation doesn't quite manage this but still the words themselves and their meaning give you an idea of what he was trying to achieve. Now I'd like you to close your eyes and just listen to the poem. Try to hear the sounds of the rain in the pine wood.

> Do you hear? The rain is falling
> On the solitary
> Greeness
> With a crackling that persists
> And varies in the air
> According to the foliage
> Sparser, less sparse.
> Listen. Nature's weeping is answered
> By the song
> Of the cicadas
> Which are not frightened
> By the south wind's tears
> Or the ashen sky.
> And the pine tree
> Has one sound, and the myrtle
> Another, and the juniper
> Yet another, instruments
> Different
> Under numberless fingers.
> --*Gabriele d'Annunzio*

It's lovely isn't it! This poem reminds me of another description of rain by John Hull.

The late John Hull was born in Australia in 1935 but moved to the UK in 1959 to study at Cambridge University. He became blind at the age of 45. Three years later in his book *"Touching the Rock*" he describes how the rain enables him to hear the surrounding environment. Once again I'd like you to close your eyes and listen to his description.

> **RAIN 9 *September* 1983**
> This evening, at about nine o'clock, I was getting ready to leave the house. I opened the front door, and rain was falling. I stood for a few minutes, lost in the beauty of it. Rain has a way of bringing out the contours of everything; it throws a coloured blanket over previously invisible things;

> instead of an intermittent and thus fragmented world, the steadily falling rain creates continuity of acoustic experience.
>
> I hear the rain pattering on the roof above me, dripping down the walls to my left and right, splashing from the drainpipe at ground level on my left, while further over to the left there is a lighter patch as the rain falls almost inaudibly upon a large leafy shrub.
>
> On the right, it is drumming, with a deeper, steadier sound upon the lawn. I can even make out the contours of the lawn, which rises to the right in a little hill. The sound of the rain is different and shapes out the curvature for me. Still further to the right, I hear the rain sounding upon the fence which divides our property from that next door.
>
> In front, the contours of the path and the steps are marked out, right down to the garden gate. Here the rain is striking the concrete, here it is splashing into the shallow pools which have already formed. Here and there is a light cascade as it drips from step to step.

It's interesting how John Hull describes his auditory experience of rain, one that many sighted people somehow miss. That is, until someone points out to them what can be heard when one closely listens. Then when it rains again they too can enjoy the soundscape it creates.

It's like vision masks our other senses. It takes precedence. It over rides them. In the process sighted people often neglect to take the time to use their other senses to their fullest extent. This is a problem if a teacher who is vision dominant is teaching a child with vision impairment and associated disabilities.

The point I'm trying to make with these two vignettes about hearing is that our senses shape the way we experience the world. Different sense abilities mean that we experience the world in different ways.

This in turn shapes who we are and how our brains are wired. To quote Aristotle "We are what we repeatedly do". (I was gong to make a little joke here and say, tongue in cheek of course, that famous expert on neuroplasticity, but I chose not too just in case I confused people in the audience). Anyway the point here is if we repeatedly experience the world in predominately visual ways then our brains are wired in predominately visual ways. This is a concern in 2017 when young children are spending so much of their time in screen based activities.

So neuroplastically speaking different sense experiences translate into different brain architecture. When I read John Hull's description of the rain to my son Chris he said that it reminds him of "Daredevil".

So now I have a quiz for you. Who knows who "Daredevil" is?

Well done! Daredevil is a blind superhero who uses his incredible hearing to fight injustice. He first appeared in Marvel Comics in 1964, then there was a film

in 2003 and more recently in 2015 it became a TV series. The story taps into the idea that if a person loses one sense then their other senses develop extraordinary capabilities to compensate. The part my son was referring to in the film was where the rain enables Daredevil to gain an auditory picture of his love interest's face.

Now I'd like you to have a brief chat with your neighbour. The topic: If someone loses one sense do they gain new skills in other senses to compensate. In your opinion and experience do you this this claim is accurate?

So what's your verdict? Can I have a show of hands for: True, False, Inbetween.

Neuroplasticity

So now it's time to move onto neuroplasticity.

Remember I said at the beginning that in simple terms, the extremely complex process called neuroplasticity, refers to the human brain's life long ability to change and adapt in response to the amount and type of stimulation it receives.

The main principle of neuroplasticity is Hebb's law, namely "Neurons that fire together wire together" (Doidge, 2007, p. 63)

When two neurons repeatedly simultaneously fire chemical changes happen that forge connections between them. These changes happen where the neurons meet at the synapse, the "junction between one neuron and another, across which nerve impulses travel" (p. 82 PositScience Companion Guide).

The interaction between the two neurons is dynamic. It involves both facilitation (helping - speeding up) and inhibition (hindering - slowing down). The process translates into behaviour that can be modulated and re-modulated.

Because it is constantly changing - if it is used the connection strengthens and becomes more sophisticated - if it is not used the connection shrinks.

Like all change, depending on the circumstances, responses can be positive or negative, helpful or unhelpful.

To recap – Hebb's law informs us that neurons that fire together wire together. That's a positive change because connections between neurons are forged. Then with repetition these connections are strengthened and new skills are learnt. When the opposite occurs the change is negative. Lack of firing together means connections fade and skills previously learnt diminish.

So stimulation is the key. Use your brain (that is, keep it occupied) or lose it (that is, the skills you already have start to diminish).

It's precisely because of these changes that teachers of children with vision impairment and associated disabilities need to be well informed about neuroplasticity and its implications for the classroom.

Five principles of neuroplasticity

So what do we know about neuroplasticity that is relevant for us as teachers of children with vision impairment and associated disabilities?

The first is use. Remember I just said that we need to use it or lose it and the most important way of exercising the brain is through sensory stimulation. Sensory stimulation is essential for neuroplasticity particularly in early childhood. Also it's not just any form of sensory stimulation. The best form is multisensory stimulation where all the senses are working together as a team.

1. Use – sensory stimulation is essential

Of course we already have a complication because, for children with vision impairment and associated disabilities, engaging in sensory stimulation can be problematic, especially if the sensory stimulation they are experiencing is neither meaningful nor pleasant.

The second principle is social interaction. Social interaction is essential, especially during the development period (that is, while the child is growing up).

Remember Vygotsky's zone of proximal development and the vital role a more knowledgeable other (MKO) plays in learning. Well this is very much the case for neuroplasticity. The child needs a more knowledgeable other (MKO) to promote brain development. This is particularly the case for the child with vision impairment and associated disabilities. They need a MKO to help them learn how to make sense of (i.e., be able to understand) the sensory stimulation they are experiencing.

2. Social interaction

Once again though there's a problem for the child with vision impairment and associated disabilities because the MKO must have specialist knowledge about the senses. Clearly it's not good if the teacher is over focused on the visual.

The third principle of neuroplasticity is that it is age related. Different types of neuroplasticity come into play throughout the lifespan.

There are two different types of age related neuroplasticity. During childhood there are waves of synaptic pruning where only those synapses that are used, and continue to be used, survive. This is called the critical period of plasticity. Synapses not established during this time are much more difficult to obtain (which explains why it's so difficult to learn a new language in adulthood if you only learnt one language as a child). After childhood, lack of use of established

pathways results in them fading, becoming dormant. They are not entirely eliminated so they are easier to re-ignite.

The critical period of plasticity during childhood occurs in three stages (waves of synaptic pruning). First there is the sensory stage, then the motor/language stage, and finally the higher cognition stage. A key consideration for teachers of children with vision impairment and associated disabilities is the initial critical period of plasticity, the sensory. This is the optimum time for sensory stimulation.

3. Age related

The point here is that for children with vision impairment and associated disabilities the sensory plays a foundational role in neuroplasticity so it is fundamentally important. Furthermore as this is a critical period of plasticity there is a limited window of opportunity. This is particularly significant because …

The next thing we know about neuroplasticity is there's a knock on effect. The fourth principle of neuroplasticity is that it changes over time. Neuroplastic changes that occurred in the past influence the nature of current neuroplastic changes and these then have an impact on future changes.

Therefore it's vital to ensure the child has the best sensory foundation experiences possible in early childhood. This includes early prescription of glasses and any other augmentative prosthetic devise needed to maximise the child's ability to effectively use their senses.

It also means recognising the powerful role rewards play in encouraging the child to stay engaged. The child must find these foundation sensory experiences enjoyable, interesting, meaningful and rewarding, otherwise they might choose not to continue to engage in them.

4. Changes over time

So to recap, we now we have four principles of neuroplasticity: 1. use, 2. social interaction, 3. age related, and 4. changes over time.

A fifth principle of neuroplasticity is there are two strands: developmental and compensatory.

Developmental neuroplasticity describes brain changes during normal development (i.e., when no problems are encountered and everything is working well).

The assumption with developmental neuroplasticity is there's a spontaneous innate process of development.

One thing leads to another and so on and so forth throughout the individual's life. So there's strong sensory development, and this lays the foundation for strong motor and language development, and this lays the foundation for strong cognitive development.

To sum up, with developmental neuroplasticity there's the assumption that the person has all their senses and faculties and that for the most part the brain is developing in spontaneous and innate ways along the lines already described.

The second strand is called compensatory neuroplasticity.

With compensatory neuroplasticity the assumption is that the person experienced developmental neuroplasticity for a period of time until something happened that caused a problem (Doidge, 2016). For example the person had a stroke and part of the brain was damaged. The brain then started to rewire in new ways to compensate for the loss. Here loss is the operative word.

5. Two strands: Developmental and compensatory

So now we have five principles of neuroplasticity: 1. use, 2. social interaction, 3. age related, 4. changes over time and 5. two strands: developmental and compensatory.

Exception to the rule

This is where it gets more complicated. The children we're focusing on today don't neatly fit into either strand. They were not born with all their senses. As a consequence their brain development does not always neatly follow the developmental path. Some parts might but there's no guarantee that all areas of the brain will develop in spontaneous and innate ways.

Furthermore there wasn't a time when their brains were experiencing developmental neuroplasticity before something went wrong so compensatory neuroplasticity doesn't neatly apply either. Remember I said loss was the operative word. These children might not have lost a sense ability. They just simply never had the ability from the start so it's not loss and compensation. I'd therefore like to propose a third stand of neuroplasticity, one that more closely aligns with children with vision impairment and associated disabilities.

I've called this third strand radical neoroplasticity. The word radical comes from the latin *radix* meaning a root. Radical means affecting the fundamental nature of something, characterised by a departure from what usually occurs.

With radical neuroplasticity we can't be making any clear assumptions. Given the vital importance of the sensory during the critical period of plasticity we must go back to the source and follow the child's sensory processing progress to determine where it is at, and if there's anything we can do to help. We can't just assume that development is going to occur. We need to be much more proactive.

I use the term sensory processing to describe the idea of the senses and perception working together. Sensory processing is an umbrella term that refers to the interface where a sense ends (i.e., the sense ability) and where perception begins (i.e., the interpretation of the sense information).

For sensory processing to occur there are three thresholds that must be crossed.

The first is the detection or baseline threshold. It refers to the lowest level of stimuli required for the individual's brain to become consciously aware of the stimuli, to notice it.

The second is the recognition threshold. This is the lowest level at which stimulus is identified by the brain as being familiar in some way.

The third is the differentiation threshold. It refers to the lowest level at which the brain can begin to compare and contrast that stimuli. For example, with hearing crossing this threshold enables the child to determine whether a noise is louder or softer, higher or lower in pitch, faster or slower than another sound. The child must pass through this threshold in order to be able to understand language.

OK so now we've talked about the sensory processing interface, the interface between a sense organ and perception, now I want to talk about another interface, this time between the neurons. It's called the neuroplastic threshold.

The neuroplastic threshold refers to the uppermost limits of one's cognitive ability. Working on a skill at or near threshold, challenges the brain to adapt. This is when the brain changes itself in positive ways. The three sensory thresholds are all examples of the brain adapting to accommodate the added experience.

Implications for the classroom

It's now time to list some implications for teaching children with vision impairment and associated disabilities.

To start with I'd like to revisit the use it or lose it idea. Put simply it's like we have a triangle. If a child uses their brain then the skills keep on developing and strengthening. You're on the positive slope. Alternatively if the child doesn't use their brain then the skills diminish and you're on the negative side. So your goal as teachers it to keep the child on the positive side of the apex of the triangle.

Kleim and Jones (2008) list nine implications that build on the use it or lose it idea. The first is use it to improve it. Encourage your students to not only use their skills but to improve them. Link the skills with functional activities. Inspire your students to do these activities more accurately, faster, with less assistance.

The second is specificity. For optimal results focus in on a specific functional task. For example, think about a particular sense ability and determine where the child is at. Can he or she detect the sense stimuli, recognise it, differentiate it

from other stimuli? Try to be specific with regards to the new skill being taught. For example at lunch time you might discover that your student is not able to visually differentiate between an orange and an apple. You could then check whether the student can differentiate the two by touch, taste, smell. Use a multisensory approach.

The third is repetition. Remember Hebb's law. Neurons that fire together wire together. Repetition is extremely important because it's the repetition that leads to the acquisition of a new skill. Also when you're trying to teach a new skill be careful to make certain that you're repeating the specific task exactly the same way each time, otherwise it's not actually repetition. Each change makes it different so then it's not repetition.

The fourth point is intensity. Remember we talked about the four thresholds. In order for change to take place there needs to be sufficient intensity for the connection to be made. You therefore need to closely observe how well the child is able to tolerate the stimuli and gradually increase it once the child is ready. For these children even mild levels of intensity can be overwhelming and tiring at first. The message here is increase the intensity gradually and don't give up. Persistence is the key.

The fifth point is time. Making connections takes time. These things can't be rushed. Also carefully observe when is the best time of the day for the child to be doing this training. Often the child is more open to such activities in the morning.

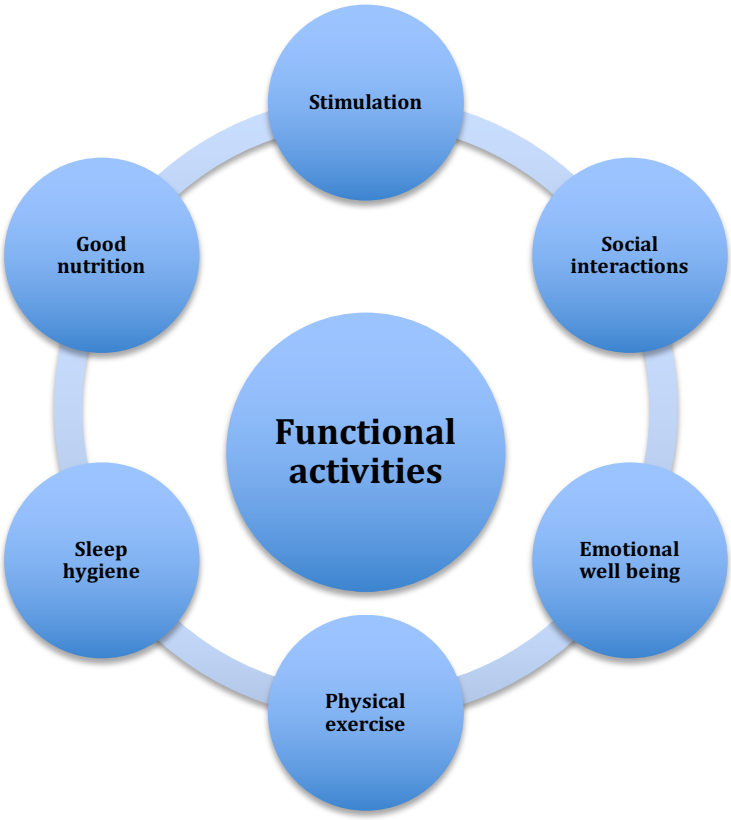
The sixth point is salience. We've already talked about this as well. For the activity to be effective it must be meaningful for the child. The activity must made sense to the child otherwise he or she won't continue doing it. So the activity needs to be meaningful, relevant, novel and rewarding.

The seventh point is age. Remember we talked about the critical period of neuroplasticity in childhood and the three stages of optimum development. Neuroplasticity occurs more easily in younger brains and during the critical periods. That said it's never too late for change to take place so it's important to maintain an optimistic attitude.

The eighth point is transference. Once a new skill has been learnt then this provides a foundation opportunity for the acquisition of a similar but new skill. It's a kind of grafting process.

The ninth point is interference. The teacher needs to be aware that sometimes a particular skill may be hindering the development of new skills. Doidge (2007) talks about plasticity having a downside in so far as we can get caught in ruts. Teachers therefore need to be careful that children are not repeating behaviours that are unproductive. An example of this would be stereotypical behaviours.

So there's always new things to learn about neuroplasticity but unfortunately we've run out of time. I'll therefore finish with this diagram, which provides a brief summary of today's talk.



Any questions?

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