A New Way to Manage Pain Using VR and AR

A portable, drug-free and surgery-free method to cut costs and remove pain

(Possibly a completely new pathway of treating pain)

At Neurotechnology we are pushing to the frontiers of what we know and seeing what we can do……

1. ***we can see the rubber hand illusion work***
2. ***we can see how mirror boxes work***
3. ***we have the VR/AR technology to reproduce these experiences in our laboratory***
4. ***neuroplasticity theory says we can leverage these phenomena to Induce neuroplastic change in sufferers from pain and stroke victims and possibly apply this to other areas***

Funding is required to explore this.

Australia's Pain Burden - A Snapshot (painaustralia.org.2017)

- One in five Australians (of all ages) suffers from pain
- One in three Australians over the age of 65 suffers from pain
- 40% of forced early retirements are due to chronic pain
- Chronic pain costs the Australian economy $34 billion per year

The Human Cost of Pain

- 30-40% of Australians presenting with chronic pain suffer from depression
- Suicidal behaviour in chronic pain sufferers is 2-3 times higher than in the general population

It is estimated that approximately **3.2** million Australians suffer persistent or chronic pain

In the **USA** (in 2012) it was estimated that **25.3** million adults suffer daily chronic pain and **23.4** million report "a lot of pain" (Nahin 2012). $100bn is spent annually treating pain ($ 50bn on back pain).

In the **United Kingdom** it is estimated that between one third and one half of the population suffer chronic pain corresponding to just under **28** million adults (Fayaz, Croft Langford Donaldson & Jones BMJ 2016).

Currently in most cases pain cannot be treated, only “managed”. Treatments include physiotherapy, chiropractic and osteopathy, surgery, tens, analgesics and implants. These services provide an ongoing and costly drain on medical resources. There is a move away from opioids as they are problematic and a move

towards psychological treatments, especially in pain syndromes where the physiological causes are unclear.

New Hope for Pain Sufferers

There are some promising and as yet not completely validated approaches emerging from within the field of Neuroplasticity. Three particular phenomena are worthy of note.

In the **Rubber Hand Illusion** experiment, a subject is seated at a table. A rubber hand protrudes from the body to create the illusion that the hand ‘belongs’ to the subject’s body. The subject’s actual hand is hidden. The rubber hand and the actual hand are touched in the same way, simultaneously. The subject looks down and therefore *sees* the rubber hand being touched but *feels* the touch on the actual hand. The brain becomes confused and reacts to the stimulus to the rubber hand as if it were the real hand. There is some evidence that there is a neurological base associated with this illusion.

Mirror Box Therapy has been used to treat (single case studies) phantom pain in amputated limbs and stroke sufferers who have unilateral deficits. The methodology involves for example, placing a subject with an amputated hand at a table with a specially designed mirror box placed on top. The subject places their remaining limb next to the mirror creating the illusion that they have two functioning intact hands placed on the table. The subject is instructed to carry out exactly the same movements or activities with ‘both’ hands. The neurological intent is seen occurring in the real hand and *as if* it is occurring in the missing or compromised hand in the mirror. Some success has been reported in treating both phantom limb pain and stroke sufferers. The mechanism is possibly similar to that of the rubber limb, in that there is an identification in the brain of the mirror limb as the real limb, and the brain is confused, with positive therapeutic effect. Some research has been carried out to validate the efficacy of these methods. The findings are mixed.

Graded Motor Imagery is an approach where as an adjunct to mirror box therapy or as a stand-alone treatment, a patient is asked to imagine/visualise an increasing range of movements outside of their actual movement range. The

theory is that by visualising a movement, the intention is created in the correct part of the brain.

There is some theory and some research that is inconclusive at this stage, but very promising.

This relates to the existence of ‘mirror neurons’ that fire off ‘empathically’ when we see something occur in someone else’s body (as there is increased empathy when one individual mirrors the body of another and increased body mirroring as empathy increases).

There is also some evidence that if we see a movement or think about a movement, this is reflected by neurological activity occurring in the parts of the brain as if we ourselves had moved. Thus in a mirror box, when the patient moves the real limb and sees the mirror limb ‘move’, the parts of the brain corresponding to the missing limb are activated, and the experience of the missing limb changes.

There is also data that reflects the strength/primacy of visual input in creating neurological activity – a visual illusion of movement is reflected by the appropriate corresponding neurological response. Patients thus simply watch material of someone carrying out the desired movement and then are asked to emulate it, with improved results.

These events when visual experience (at times of virtual body ownership) generate actual neurological change, are the keys to the neuroplastic component of our proposed solution and possibly provide a completely new approach to pain and physical rehabilitation.

A limitation of the rubber hand methodology and the mirror box is that their utility is limited to the bilateral limbs, and/or where at least one limb as to be perfectly functional.

Our Solution

Virtual Reality and **Augmented Reality** allow us to create compelling experiences for people.

Virtual Reality is already being used to help in the management of pain as a distraction technique. Burn victims, for example, are distracted by being placed in a soothing and compellingly distracting environment while their wounds are being treated.

VR games have also been devised that distract children while they are given injections or have to undergo other procedures in which the procedure is incorporated into the game.

There are a number of rehabilitation software packages where physiotherapy exercises are incorporated into **VR** and **AR** games so as to increase motivation and mobility through distraction. There are also **VR** applications that create or recreate phobic experiences for the purposes of exposure and desensitisation.

Most of these current treatments simply utilise VR/AR as an adjunct to existing therapy modalities.

A central principle of Neuroplasticity, is the notion that the brain cannot tell the difference between actual experience and perceived experience. Virtual reality technology allows us to create compelling perceptions that people can engage with *as if* they are real.

Neurotechnology has constructed a 'virtual mirror box' – called the *tranceducer* (tm). It allows for a real time experience of the self and the 'mirror self'; it also allows for visual representation of both the pain experience and the neural pathways pain would travel in the real body. Instead of a rubber representation of the body, it is a virtual representation. It also allows a 'mirror' representation to be created of the entire body rather than simple symmetrical opposing limbs. This representation is more detailed and the viewer is able to experience 'themselves' at a muscular and nervous system level. This provides people with a completely different experience of themselves at a biological level, and may unlock great neuroplastic potential

The VR/AR environment thus allows us to access a virtual mirror box and a virtual rubber hand and create an 'avatar' that subjects deeply identify with as themselves; this 'self' can simultaneously engage in a therapy context physically, visually and psychologically. The self is both inhabited and seen in a 'mirror'. This leverages the therapeutic potential of all three mechanisms, not only engaging the mirror neurons but also shifting brain activity using the power of immersive, visual experience together with tactile and motor engagement. It is hypothesised that this multisensory tool will facilitate the training of pain sufferers to reduce/eliminate pain in the long term.

The tranceducer has been witnessed to be engaging and realistic in providing the self and mirror self-illusion. We are starting single case studies to trial the product and further develop the therapy protocols.

The tranceducer is initially intended for use in the management of pain of all kinds, we will start with carpal tunnel syndrome, neuropathic pains, chronic

regional pain syndrome and various soft tissue injuries. The tranceducer allows us to work with all kinds of pain, regardless of the location in the body (including lower back pain, headaches, TMJ pain).

Neuroplastic theory holds that chronic pain becomes an entrenched learned response both psychologically (mediated) and as a well-travelled neural pathway. Chronic pain in the absence of a physical cause, or in the presence of an ongoing (but stable and non-malignant) physical cause is perhaps an example of neuroplasticity gone wrong. The proposed methodology *cognitivr(tm)* combines proven existing therapeutic modalities with the added power of a compelling VR/AR experience.

We wish to perfect our prototype and explore its potential for pain management and its generalisation to lasting neuroplastic change. Once this is proven, the *cognitivr* methodology can be extended to a number of other treatments. It is hypothesised that this methodology will engage with and reduce pain in a way completely different to any current methodology and may be able to *cure* pain (remove it) rather than simply *manage* it. This is done by focussing on neuroplastic change, and re-educating the client and their bodies into a new experience of their pain and its modulation.

Once the efficacy of the model has been proven, it is anticipated that programmes will be created for home use of a self- treatment protocol with online assistance.

Although the initial focus is on pain, the tranceducer is also able to be used for stroke rehabilitation and recovery/management of other conditions.

References are not included but are available on request.