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'Perception is an illusion'

♬ *Imagine (John Lennon)*

It's early evening in the Care Home as the last few bars of *"Imagine"* drift from the piano and out into the evening air. Bob the musician marvels at the cadential chord sequence, impressed by the skill of the young pianist. He is visiting his sister Gwyneth who has no idea who or where she is but beams as she remembers the first time she danced to that very song fifty years before. Stacey the care worker looks on, wondering what she will do when her long shift ends, unaware of the music until the last note fades. All three have been subject to the same patterns of vibrating air hitting their eardrums and photons of light entering their eyes, yet their interpretation and reactions are so different. How can this be? How does the physics of the external world become the inner narrative that guides our existence? How do past experience, drugs and disease modify our perception and can we really ever dismiss perception as an illusion? To explore this intriguing question let us take a journey through what is known of the brain towards the mysteries of the mind.

♬ *Can you read my mind? (The Killers)*

Philosophers have questioned the nature of perception since ancient times, yet as a generation we are poised to find answers that may expand our knowledge far beyond what has come before. Revolutionary advances in modern neuroscience have given us access to quantitative techniques that can be used to measure the inner workings of the conscious brain, allowing us to begin breaking down the barriers between our concepts of mind and brain. With new technologies, questions previously addressed philosophically can now be approached from a more objective scientific perspective. As an example, let us consider what would happen if we were to monitor the brain activity of the three people back in the care home as they listen to that same song. A recent study in *Neuroscience Letters* described differences in brain activity when musically trained and non-musically trained people listened to music.[1] Using functional magnetic resonance imaging it was shown that when listening to a particular series of auditory stimuli, certain neural networks were only recruited by the musicians. Melodic processing activated the most anterior part of the superior temporal gyrus for everyone, but harmonic processing activated different visual association areas for musicians relative to non-musicians. Other studies have shown different functional responses to music in those with and without dementia and between 'active' and 'passive' listening. Thus, behind the three different perceptions of Gwyneth, Bob and Stacey, there is quantifiable evidence that their brains are interpreting and responding to information in different ways depending on each person's knowledge, experience and pathology.

♬ *It's just an illusion... in all this confusion (Imagination)*

To address the question of whether or not perception is an illusion we must consider how an illusion is defined. In common use, the term illusion is often applied to something which is not 'real'. The oasis we see in a mirage does not exist in the physical world and may therefore be classed as an illusion. But remember the three volunteers in the scanner we considered earlier. The functional MRI highlighted differences in perception that could be measured and explained, demonstrating perception to be a process grounded in the physical world. So if we scanned the

brains of two thirsty travellers in the desert, one seeing a mirage and one not, it certainly seems conceivable that there would be measureable differences. The illusion would then be shown to have an underlying physical correlate. So perhaps rather than defining an illusion in terms of the 'real' and the 'unreal' we should consider a more mechanistic explanation where an illusion is simply a misinterpretation of the inputs our brain receives from our senses that leads us to the wrong conclusion. So let us consider what factors can alter our perception and why these might be important.

♬ *The long and winding road (The Beatles)*

We are continuously bombarded with sensory information from our environment. To make sense of these inputs requires formidable information processing by our brains. Let's use the example of a delicious hot cheeseburger sitting in front of you. You're hungry and you want to eat it, even if it is the first time you have encountered it. The pre-frontal cortex, consisting of grey matter, is the part of the brain responsible for higher cognitive functions and thus is associated with the construction of conscious perception. In the process of analysing nervous impulses from the sense organs, the pre-frontal cortex combines environmental context and previous experience to derive meaning. This may include processing the sensory impulses generated by yellow light hitting your retina from the delightful cheap melting imitation cheese. Alone, this colour perception means little; when put in context with the familiar smell and your hunger, a desire to eat is generated. A vegetarian, on the other hand, may have a completely different response . . . The significance of these two factors, context and past experience, partly explains why two people subject to similar sensory inputs can have such different experiences. Assuredly, both are fundamental in modulating our perception.

In fact, these principles are applicable to all forms of sensory input. Take pain, for example. It may seem intuitive that the intensity of pain experienced should correlate with the severity of tissue damage, however the relationship is not so simple. Individual experiences range from the inability to feel pain at all to feeling phantom pain in an amputated limb when no physiological cause is present. The fact that individual experiences of pain can differ so wildly emphasises that the perception of pain is a subjective experience, not the sum of the impulses travelling along pain-sensitive nerves. Applying the same rationale to our other senses, we see that our brain cannot ever be showing us 'true' reality, only a reconstruction that is specifically tailored by our individual experiences.

♬ *Stayin' alive (The Bee Gees)*

So why do we perceive pain? Nociceptors are the sensory neurons that respond to harmful stimuli, propagating action potentials towards the brain. The nociceptive system serves as a defence mechanism, as the ability to detect and respond to danger quickly conveys a survival advantage. Furthermore, not only is there an immediate response to minimise tissue damage when the painful stimulus is introduced, there are also longer-term associations made with aspects of the dangerous situation so that extra precautions can be taken in future. If you are stung by a bee as a child, you are more likely to be cautious around buzzing yellow and black insects for ever. Again, parallels can be drawn between pain and other forms of perception by applying the same logic to the other senses. Arguably all our senses are there to guide adaptive behaviour, allowing us to learn through

experience and react more efficiently in similar future situations. This notion of evolutionary survival benefit is likely to be a key reason for the existence of perception. If perception is an illusion, then it is an illusion with clear survival benefits.

♬ *Lights will guide you home (Coldplay)*

We feel like we experience the world around us in its entirety, particularly with regard to our visual surroundings. Yet our eyes are only sensitive to a tiny proportion of the electromagnetic spectrum and optical illusions demonstrate that even within this range our vision can be misleading. When you look at shapes with missing parts, you will often still see them as the complete shape. Perhaps it seems that your eyes are telling you the wrong thing but such illusions actually demonstrate a very useful function performed by the brain. Using the statistics of most probable outcome, it is generally useful in day-to-day life to fill in gaps, making predictions based on incomplete information. Although such shortcuts may occasionally fail, this is an extremely efficient mechanism that works effectively the vast majority of the time. Indeed, the speed and efficiency of our perception in a remarkable achievement of the human brain.

♬ *A spoonful of sugar (Mary Poppins)*

To further illustrate this remarkable efficiency of our brains, let's do a quick thought experiment: There are 100 trillion synapses in the brain connecting complex networks of neurons. The electrical impulses passed along these cells are the fundamental basis for the processing and interpretation of all sensory stimuli we encounter. However, the initiation and propagation of these action potentials is expensive in terms of ATP. Assume there are 10^{12} neurons in the brain and that one single action potential requires roughly 3.4×10^{8} ATP molecules.[2] If every neuron produces up to 100 AP per second when processing lots of information, then 0.27g of glucose would need to be metabolised each second. To put it in context, this roughly equates to drinking 20 litres of golden syrup every day, which is clearly ridiculous! Of course my guesstimate above will have errors in approximation due to multiple ignored factors such as efficiency differences between myelinated and non-myelinated neurons. However, the point still stands that it is impossible for such high energy demands to be constantly fulfilled. The brain is in fact presented with far more information than it can represent, working on only 20 Watts of power. Yet we still manage for the most part to make sense of our surroundings. This is only possible because the brain has evolved to be extremely economical with its energy usage; we take shortcuts and make guesses based on previous experience as we perceive the world around us. If perception is an illusion, then it is a highly energy efficient one.

♬ *There's too much confusion, I can't get no relief (Jimi Hendrix, All Along the Watchtower)*

Having examined the extent to which perception performs useful functions, let us consider situations where this normal brain function is disturbed. Certain disorders of the mind can have huge influences on perception. For example, patients with Alzheimer's disease may experience visual hallucinations due to degradation of their sight. Here, the primary cause may be visual impairment, but Alzheimer's patients may be less capable of the accurate perceptual guesswork required to make sense of the visual world around them. In schizophrenia, auditory hallucinations may be heard in the form of voices. It is clear that people with such perceptual disturbances face

more difficulties with certain tasks and managing on their own, highlighting the importance of normally functioning perception. When the brain function breaks down, such that perception becomes illusion, the resultant confusion may compromise all aspects of our lives.

♬ They tried to make me go to Rehab (Amy Winehouse)

Disease is not the only factor that may contribute to a decline in perceptual ability. What happens when we mess with the brain in other ways? Recreational drugs are renowned for their ability to distort reality. Drug-induced hallucinations, such as those experienced during LSD or ecstasy highs, are usually visual but the same principles apply as with mental disease. Nobody else can can hear the voices inside the schizophrenic's head just like nobody else can see the rainbow-coloured monkeys dancing in front of the tripping drug-addict. Yet there are instances where regardless of the type or realistic feasibility of a hallucinogenic experience, the misinterpretation can be so convincing that people become deluded. Whether it be drug-induced or a result of mental disorder, delusion really demonstrates the power of the human mind. It shows that we are forced to believe the things we experience as real as it is impossible to know any better. It is easy to regard the hallucinogenic images or feelings as illusions when we consider them from an outside perspective. However, as soon we try and do the same for normally-functioning minds, this concept of an exterior perspective becomes redundant as it cannot physically be achieved. In applying this logic, we must accept that there is no point trying to gauge the nature of perception by searching for illusionary concepts outside of it. All we can ever know is what our perception tells us.

♬ What a wonderful world (Frank Sinatra)

We have seen that our perception is a uniquely personal algorithm that efficiently converts the immense complexities of the external world into the experiences which guide our lives. Is it a perfect representation of reality? Not at all. Instead it's better than that. One could argue that evolution has driven the development of our perceptive skills in a way that deliberately masks reality in order to give the greatest ultimate benefits. Perhaps this is the case or perhaps not. Regardless, when we consider situations where perception breaks down, it is clear that normal perception is hugely advantageous in terms of survival. Perception is the one tool we have to guide us through our world. It is the only access we can ever have to any kind of understanding. To dismiss perception as an illusion and suggest that this crucial tool is actually misleading or unreal is surely absurd, as it arguably undermines our existence altogether.

Citations:

[1] Schmithorst VJ, Holland SK. The effect of musical training on music processing: a functional magnetic resonance imaging study in humans. *Neuroscience Letters* 348 (2003) 65–68

[2] Sengupta B, Stemmler M, Laughlin SB, Niven JE. Action Potential Energy Efficiency Varies Among Neuron Types in Vertebrates and Invertebrates. *PLoS Computational Biology (July 2010)*
(My calculations are based on the measured ATP consumption (cm^{-2}) of an action potential in a mouse thalamocortical relay neuron.)