How Does Jujitsu Change Your Brain?

Neuroplasticity, Motor Learning and Jujitsu

Uchikomi and butsukari in Japanese Jujitsu represent the processes undergone in order to attain “muscle memory” and allow the execution of a technique in high-stress situations without reverting to the instinctive, primal responses to stress-induced release of adrenaline, noradrenaline and cortisol and their physiological effects. The term ‘muscle memory’ is frequently used to describe the outcome of learning and perfecting a procedural skill, applicable to both basic daily activities and martial arts techniques. Despite its widespread usage, ‘muscle memory’ is inaccurate as neither the muscles nor basic spinal reflex pathways undergo change throughout training; rather, it is the underlying motor pathways that originate from the brain and its cells (neurones) that experience remodelling, or neuroplasticity, leading to motor learning. This essay aims to outline the basic mechanisms of neuroplasticity and motor learning in order to investigate their applications to the practice of jujitsu.

Neuroplasticity is essential for all learned human behaviours and skills including language. It describes the modification of individual neurones and also the connections between these neurones or neural pathways. When the term is applied to learning and memory, it describes changes in the strength of connections between neurones (synapses) and even between different networks of neurones throughout the brain depending on their patterns of activation. Repeated performance of an activity or rehearsal of a fact can increase the strength of neural connections involved or long-term potentiation (LTP) whereas the lack thereof can decrease the strength of these connections or long-term depression (LTD). These changes occur through physical modification of synaptic structural scaffolding, altered chemicals and neurotransmitters (small chemicals produced by neurones for signalling) and their concentrations in these synapses and even adjustments in gene expression¹. The mechanisms through which these changes occur differ between networks and depend on intrinsic neurone characteristics. Individually, the consequences are comparatively minimal, as in short-term neuroplasticity; however, in procedural learning and memory, these changes occur simultaneously in multiple areas of the brain including the cortex – responsible for higher thought functions, sensory perception and movement initiation, the cerebellum – involved in coordination and balance, and the hippocampus – for declarative (conscious) memory formation². By maintaining the repetition, these networks and connections are further strengthened to the point that instantaneous recall and
motor performance can occur with minimal conscious effort and better coordination. When under stressful conditions, the physiological effects of stress hormones released can disrupt higher-order thought processes and preferentially follow signals from the brain structure known as the amygdala, which is responsible for emotions and fear- and anger-related responses. The process of neuroplasticity instigated by jujitsuka by practicing techniques in a controlled environment eliminates the need for these complex thought processes and allows skill execution even under high stress conditions. This is the underlying scientific basis for uchikomi and butsukari.

Additionally, components of general exercise are incorporated in jujitsu training sessions primarily to develop the physical endurance and strength required to easily perform techniques for extended periods of time and delay physical exhaustion under pressure. As a result, practicing jujitsu increases blood flow and nutrient delivery to the brain from the increased cardiovascular fitness. Many jujitsu techniques require coordination of both sides of the body, and the ability to reflect a skill with the non-dominant side, resulting in neural adaptations required for this coordination between and within hemispheres of the brain. When combined with the increased blood flow, this can positively impact other mental functions in daily life, even those that do not involve complex motor sequences. The physical activity inherent in jujitsu practice also decreases risk of chronic and potentially life-threatening conditions such as heart disease (including heart attacks), stroke and diabetes.

Obviously, when these techniques are learnt and first practiced, attention is required for neuroplasticity to occur. Attention is a prerequisite when children learn actions because they are unfamiliar with the majority of movements that adults accept for granted. As a result, it can be easier for children with the required focus and concentration to learn sequences of movements than it is for an adult. In adults commencing jujitsu or any martial art, it is important to emphasise aspects requiring conscious attention, including finer details and adapting to different training partners, to encourage development of new neural networks and accelerate their learning. More complex, intricate and ‘artistic’ techniques are generally learnt at higher ranks after being deemed proficient in basic techniques. This not only provides an incentive to continue training, but also maintains their attention and focus with difficult techniques to improve the learning thereof and also allows the brain to build upon and adapt pre-existing connections gained from practicing basic techniques.

These two practices can also be related to motor learning. Gatti and colleagues (2013) define motor learning as “the process through which we come to
perform actions effortlessly after practice and interactions with the environment.” Unsurprisingly, this is very similar to the description of ‘muscle memory’ in jujitsu. This is essentially neuroplasticity when exclusively applied to motor skills. The physiological process involves multiple interacting sensory components, decision-making strategies and motor control processes: there are also distinct learning phases involved – fast (one training session), consolidation (>6h from training), slow (several training sessions), automatic (automatic execution) and retention (execution without practice)³. Different neural pathways for motor and spatial coordination are involved in different skills and in each of these phases, with sequential recruitment in slower learning and parallel recruitment in fast learning. Involvement of multiple learning pathways in jujitsu facilitates faster learning. For example, increased repetitions in one training session for fast phase learning, and attending multiple sessions in one week for consolidation and slow phase learning; intensive immersion training programs lead to even greater improvement. Focussed goals in jujitsu, the self-discipline to accomplish these goals and the perseverance involved in repeating motor techniques for motor learning are thus crucial to improvement in martial arts, as in other areas of life.

Molecular mechanisms occurring in living humans are difficult to investigate; however the strategies of motor learning can be studied by their behaviour. Action observation is commonly used in jujitsu when a sensei or sempai demonstrates a technique. By observing these actions being formed by another individual, neurones that would generate the same action actually activate in the observer; these specific neurones form the mirror neurone system, important for learning behaviour through observation⁴. These neurones also show the ability to adapt pre-existing connections, which enables even highly skilled martial artists to modify known and learn new techniques through observation. Consequently, learning techniques from YouTube and other videos are a valid method of consolidating and expanding one’s repertoire. Actions and sequences are also learnt better if they are shown then performed in the same context. Accordingly, it is easier for a student to apply an arm bar as a defence when its application is first demonstrated by the instructor, rather than the pure technique.

Physical practice may be the most efficient method of motor learning, however it is not the only method of strengthening the neural connections formed after a martial arts class. Mentally visualising certain movements or gestures while otherwise stationary⁵ has also been shown to improve learning of these actions⁶. This is known as motor imagery and is associated with the brain regions responsible for initiating and controlling spontaneous movement, and storing
learned motor sequences\textsuperscript{6}. In comparison, motor training through physical action preferentially develops areas of the brain associated with coordination and initiating movement in response to external stimuli. Multiple networks can thus result from motor imagery combined with motor training and has the potential to enhance performance\textsuperscript{6}. This is done by integrating sensory modalities, incorporating multiple brain structures and a larger range of functions, therefore enhancing neuroplasticity and learning\textsuperscript{2}. Though it can be difficult for younger children to maintain the necessary concentration, they can do so briefly after each class to enhance their learning experience. This phenomenon is more important in adults with health issues preventing extended periods of highly active movement or with work and family commitments limiting time they are able to spend in a dojo. During meal breaks, while at home, when on public transport or even when sitting in traffic, it is possible for a dedicated martial artist to mentally rehearse the movement sequences that they are familiar with and strengthen the mental connections that allow these movements. Following that, when they are able to return to practice, they will have retained their knowledge of techniques and can focus on learning rather than worrying about what they have forgotten.

The current theories of underlying mechanisms for learned motor behaviours, which can be maintained over an entire lifetime, are postulated to be different to conscious memories, which are easily remembered then forgotten\textsuperscript{7}. The retention state of motor learning also indicates that these previously learnt motor skills could still be demonstrated after a long period of time without practice. This suggests that children who have previous experience with martial arts will be able to demonstrate these skills if required in a self-defence situation, even if they have stopped training. This concept is equally applicable to adults, though it may take longer for the skills to be learnt due to increased attention required for motor learning in adults, as elucidated previously.

Understanding some of the mechanisms underlying learning techniques in jujitsu enables jujitsuka to apply this knowledge and learn more effectively and more efficiently. Some strategies that have been suggested include: beginning the martial arts journey at a young age; increasing difficulty of techniques learnt with age and experience; consistently attending training sessions and attending multiple sessions each week for maximum repetition of techniques; observational learning through online and instructional videos; demonstration of techniques in relevant, applicable situations; and mental rehearsal of learnt motor sequences. These concepts may have further applications that have not been explored in this essay, such as jujitsu training as a method of rehabilitation as the changes that occur with learning new skills and development of new
pathways can form bridges and replace the connections lost in spinal or brain injury.

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References


