Why the Sensory Experience is Essential for Functional Recovery

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1. Indications for a Sensory Approach

A sensory approach is essential to any physical therapy and rehabilitation plan, especially considering the influence of sensation, whether interoception or exteroception, has on neuroplasticity in patients with neurologic or musculoskeletal conditions. The application of sensory strategies can enhance outcomes through integration, desensitization, and tone modulation approaches.

A sensory integration approach can be used in any rehabilitation case with neurologic or musculoskeletal impairments, but especially those with:

- Difficulty tolerating manual contact or touch,
- Reactivity with grooming activities (bathing, nail trims),
- Difficulty maintaining a calm, alert, and organized state,
- Difficulty calming down and falling asleep at night,
- Difficulty transitioning between activities,
- Difficulty identifying when he is hungry or needs to potty, or
- Sensory integration disorder/dysfunction, tactile defensiveness, or sensory-based anxiety.

Sensory Integration Disorder/Dysfunction (SID) is the inability to take in, integrate, and have a meaningful response to sensory stimulation (Kapes 1995). SID subtypes, defined by Ayers in 1979, include: disorders involving the vestibular system, developmental dyspraxia (a motor planning problem), tactile defensiveness, and visual perception and auditory language disorders. Sensory processing disorders (SPD) have been recognized in companion animal medicine.

A desensitization approach is indicated when there is sensory defensiveness as a result of recent trauma or amputation. Maladaptive neuroplastic changes following these injuries might lead to Complex Regional Pain Syndrome (CRPS), Reflex Sympathetic Dystrophy (RSD) or Phantom Limb Pain/Sensation (PLP/PLS). As well, peripheral nerve injuries might lead to conditions in which the perception of pain is out of proportion to the severity of the initial injury.

Sensory defensiveness is an overactivation of CNS protective responses, a negative reaction to harmless or non-irritating sensation, or overly sensitive, reactive, emotional, or responsive to a sensation. Children with sensory defensiveness are often sensory seeking and might hit, bite, body-slam or bump into people or objects, jump excessively, or have temper tantrums. Some of these same behaviors are noted in animal patients with sensory difficulties.

A tone modulation approach is indicated when there is hypertonia, hypotonia, or in preparation for a physical therapy or rehabilitation activity. Sensory techniques, first described and utilized in neurorehabilitation by Rood (NeuroDevelopmental Treatment (NDT)) and Kabat, Knott, and Voss (Proprioceptive Neuromuscular Facilitation (PNF)), alter neuromuscular tone, allowing for improved motor activation and control during functional activities.

2. Threat Response and Adaptive and Maladaptive Neuroplasticity

Perception of sensation can result in responses which vary from discrimination (immediate interpretation of stimulus and response), to protection (basic, survival-oriented response, fight, flight or fright), to sensory defensiveness (over-responsiveness or overactivity of protective responses). A sensation might be interpreted as a threat due to its association with nociception/pain (sensation/perception), inflammation, harm, stress, fear, anxiety, or hyperarousal.

When a threat is detected, the nervous system uses the reticular activating system (RAS) to prepare the motor system to respond with fight, flee, fidget, freeze, fawn, fright, flat, or faint. This also results in a cascade and release of neuro-immuno-endocrine chemicals including norepinephrine, epinephrine, and cortisol. The autonomic nervous system also responds to threat with dilation or constriction of pupils, an increase or decrease in body temperature, holding of breath, an increase or decrease in muscle tension, nausea, lightheadedness, signs of vertigo, pain or increased sensitivity, and/or a possible inflammatory response. These physiological responses to the threat are counter to recovery and can result in maladaptive neuroplasticity.

Maladaptive neuroplasticity via cortical mapping or “smudging” can result in weakness, immobility, neglect, neuropathic pain, phantom limb pain or sensation (PLP/PLS), complex regional pain syndrome (CRPS), sensory integration disorder or dysfunction (SID), sensory defensiveness, or paresthesia and is associated with reduced sensory discrimination and awareness. Alternatively, our goal of adaptive neuroplasticity results in enhanced quality of life, improved comfort, and recovery of function. Adaptive neuroplasticity relies on synaptic and structural plasticity. Synaptic plasticity refers to changes in the strength and effectiveness of connections between neurons, whereas structural plasticity refers to the development of new brain pathways and synapses.

3. The Sensory Experience: The Physical Therapy Process

The animal physical therapist follows a specific process in integrating a sensory approach with a traditional or Activity Based Therapy (ABT) plan of care. This includes performance and interpretation of the evaluation, introduction of an appropriate sensory stimulation protocol and integration of that protocol with Activity Based Therapy (ABT) interventions, and instruction of the client in home activities and interventions which support the therapy plan.

The sensory evaluation as performed by the animal physical therapist will include tests for conscious proprioception, withdrawal, deep pain, spinal reflexes, dermatomal sensation, cranial nerve function, deep tendon reflexes, and neurological reactions and responses. The results of the testing are important to correlate with the medical diagnosis and localization of the "lesion" but just as important is the interpretation of the results for use in the animal physical therapy treatment plan.

4. Sensory Strategies

The overarching goal of integrating a sensory approach with Activity Based Therapy interventions is to remove the threat and increase the motivation for adaptive neuroplasticity. When the threat is removed, cortisol is less likely to be released, and the likelihood of functional recovery is increased.

There are two theories with regards to pain modulation or management. These can be used in sensory approaches to promote adaptive neuroplasticity and reduce the risk of maladaptive neuroplasticity after injury. The Gate Control Theory (Melzack and Wall 1965, Noordenbos 1959) is when non-painful stimuli close the "gate" to painful stimuli and prevent painful sensation from travelling through the CNS. Thick, myelinated, fast fibers (eg., touch, pressure, vibration, intense/quick duration pain) excite inhibitory signals (cause inhibition) while thin, small, unmyelinated, slow fibers (eg., throbbing, longer duration pain) inhibit inhibitory signals.

The NeuroMatrix Theory (Melzack 1990) is a more modern theory and suggests that perception of nociceptive stimuli is not from passive awareness of tissue trauma or peripheral activation of receptors, but from active generation of subjective pain experiences by the brain through a network of neurons based on various factors, including sensory input, emotions, and past experiences. This resembles our current understanding of neuroplasticity.

Desensitization is a therapeutic program reintroducing normal touch and temperature to hypersensitive areas with goals of calming hypersensitive nerves, reducing pain, and remapping the brain with regards to normal sensation. The hope is to:

- Improve function or use of a limb,
- Improve sensation and sensory awareness,
- Improve proprioception,
- Increase relaxation during sensory stimulation therapy,
- Reduce excessive nibbling, licking, grooming, chewing, or biting, and
- Improve comfort.

Sensory integration (Stephens 1997) is the ability to take in sensory information, combine it with other information stored in the brain, and produce a meaningful response. The hope is for:

- Increased overall self-regulation,
- Decreased anxiety to sensory triggers,
- Improved ability to transition between challenging tasks (and attend to task),
- Improved organization of sensory information, and
- Increased calm (eg., more easily falling asleep).

Tone modulating sensory approaches address hypotonia and hypertonia. Hypertonia frequently is confused for strength, however, when tone nomalizes, there can be underlying weakness. Tone can be altered by:

- Stress,

- Body temperature,
- Pain,
- Body position,
- Medical status,
- Medication,
- CNS arousal, and
- Degree of volitional movement.

Margaret Rood described tone altering stimuli which could increase muscle tone, including:

- Approximation or compression,
- Quick application of ice,
- Light touch,
- Quick stretch,
- Resistance,
- Manual contact or withdrawal,
- Tapping,
- Vibration, and
- Brushing or scratching.

And stimuli which could decrease or inhibit muscle tone, including:

- Prolonged stretch,
- Deep tendon pressure,
- Warm or neutral temperature,
- Prolonged icing (ie.,15-20 minutes),
- Slow stroking, and
- Rhythmic rotation, rocking, shaking, or rolling.

Positive responses to a tone modulating protocol include: improved tone, improved volitional motor activity, and improved motor control.

With any sensory protocol, a positive response includes improved function or use of limb, improved sensation/sensory awareness, and improved comfort. An adverse response might include increased anxiety, an attempt by the patient to escape, move, or pull away or withdrawal from the stimulus, increased neurosensory signs, any sign of pain or discomfort, increased nibbling, licking, grooming, chewing, or biting, or self-mutilation. With regards to outcomes, it is suggested that clinicians objectively measure progress with regards to changes in medication use or need, grooming and/or self-mutilation, limb amputation or salvage, limb usage or function, pain, and sensory awareness, in order to assess response to a sensory approach.

5. Graded Exposure Therapy

Graded Exposure Therapy is a recommended approach when for introducing sensory stimuli in order to prevent a negative response. In this approach, the therapist must regularly test and re-test/assess and re-assess, and focus on activating intact pathways for an adaptive neuroplastic effect. In GET, the therapist provides gradual, progressive exposure to the potentially threatening stimulus, first exposing the patient in a non-threatening area (with normal sensation) at the lowest level (eg., intensity, pressure, duration, and speed) threat without intent to cause harm and assuring the patient that they are safe. There is a slow progression from least to greatest threat, while gradually increasing intensity, pressure, duration, and speed of application. It is important in GET to avoid flare-ups. Stimuli used in GET can include tactile, mechanical, thermal, electromagnetic, or chemical stimuli.

When using GET, there is a reduced risk of the patient developing neuropathic pain, phantom limb pain/sensation, and paresthesia (maladaptive neuroplasticity), increased accuracy of the cortical map, improved sensation, body awareness, and motor control, reduced pain, and improved tissue tolerance to varied sensory inputs.

6. Sensory Treatment Tactics

Sensory treatment tactics employed by animal physical therapists include manual techniques, tape (eg., kinesiology tape) and sensory garments (eg., K9 Align, Thundershirt), tools and instruments (eg., IASTM tools, brushes, vibrational and massaging devices), electrotherapeutic modalities, exercise equipment, and alteration or enrichment of the treatment or living environment.

Manual techniques provide stimulation to sensory receptors for feedback and augmentation of sensory feedback, facilitation and normalization of neuromotor tone, assistance or resistance for functional mobility and gait (ie., patient handling), and can be used in multi-modal Activity Based Therapy for repetition and to strengthen an active response for motor learning in order to promote functional independence. Mechanical assistive devices “free up” the animal physical therapist’s hands, making application of these techniques more efficient and specific. Pelletier, Bourbonnais, and Higgins 2018 suggest that “the neurophysiological effects associated with manual therapy involve a limited number of studies with small sample sizes” and that most have studied transient and short-term effects.

The NDT and PNF approaches include that of manual contact during therapy, in which the contact of the hand on the body surface over a muscle group facilitates contraction of that group by stimulation of receptors and improving awareness of that muscle group. Lesemann, Reuter, and Godde 2015 not that “the pure exposure to extensive tactile stimulation, without the requirement of attention or active training, has been revealed to enhance sensorimotor functioning presumably due to an induction of plasticity in the somatosensory cortex.”

Kinesiology taping has led to increased attention during movement/exercise and increased cognitive-attentional processing of stimuli during exercise in patients with total knee arthroplasty (Albizzati et al 2020).

Electrotherapeutic modalities have also demonstrated promise with regards to a sensory approach. Yingshan et al (2024) reviewed 101 studies of electroacupuncture (EA) and noted that EA significantly improved ischemic stroke rat’s postsynaptic density thickness, numerical density of synapses compared with non-EA-treated, and improved parts of biomarkers of synapses, neurogenesis, angiogenesis and neurotrophin activity than the control group.

7. Environmental Enrichment

Of great interest is the influence of the environment, especially that which is enriched, for promoting adaptive neuroplasticity and functional recovery. Environmental Enrichment (EE) is described by Wurbel et al as “providing a multi-faceted physical environment (for work, play, living) that enhances motor, cognitive, sensory and social stimulation, relative to standard conditions (1998). EE benefits patients by: Increasing rate of synaptogenesis, complexity of neural connections, and brain activity, stimulating learning, memory, and sensory areas of the brain, reducing stress, improving cognitive and gross motor function and recovery from brain injury and stroke. It is also known to delay onset, slow progression, and/or reverse symptoms of schizophrenia and autism spectrum disorders.

A study of rats with SCI on "crate rest" suggested that there was improved functional recovery when the rats were returned to a less restrictive home environment rather than being immobilized in a tube or restrictive wheelchair.

Researchers have also noted that there is a need to allow free access to an enriched environment without time limits. Running wheel exercise can enhance neurogenesis if there is access to the wheel for 24 hours/day (van Praag et al, 2000; Voss et al, 2013). If the access is limited, there are more modest effects (Nguemeni et al, 2018).

Based on this, there are suggestions with regards to alteration of the physical environment in order to promote neuroplasticity and functional recovery. Researchers suggest that there are:

- Obstacles for climbing and jumping,
- Structures for hiding/retreat, sleeping/rest, or nesting,
- Floor space for sleeping, eating, and eliminating,
- Considerations made for the substrate/surface (ie., variable temperature, texture) for sleeping, standing, and walking,
- Vertical vantage points (ie., variety of heights), and
- Environmental complexity.

Novel feeding strategies are also suggested which encourage locomotion and cognitive stimulation, promoting predator-prey drive, locating/localization, capturing, killing, and processing food.

When combined with physical exercise, EE promotes nesting, climbing, and navigation of obstacles stimulating balance and strength. Ideally, an EE approach progresses from simple to more elaborate, is social, includes movement, stimulates the patient cognitively, and includes novel tasks and other sensory stimulation

Overall, there is a need for animal physical therapists and other rehabilitation professionals to consider the sensory experience of the animal patient, whether applied, augmented, enriched or manipulated, to maximize beneficial effects, adaptive neuroplasticity, and functional recovery.

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