ALLODYNIA OF THE HAND

DEFINITION, ASSESSMENT, AND TREATMENT OF ALLODYNIA OF THE HAND: AN INTERNATIONAL DELPHI STUDY

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Lay Abstract

Allodynia is when pain is caused by something that would normally not be painful such as a light touch or mild temperatures. It occurs when nerves become overly sensitive, and if this happens in the hand, it can limit how people use their hand and cause distress. There is little research to guide therapists and conflicting advice in textbooks on how to treat this. To help fill this gap, we conducted four online surveys with hand therapy experts.

We found that expert therapists recommended assessments and treatments that look at how the person with allodynia is functioning and managing the pain. However, they disagreed on whether the painful area should be touched or not. This is important as it influences the advice given to clients and how treatment is delivered. More research is needed to compare approaches and to figure out what factors may influence how people with allodynia may respond to different treatments.

Abstract

Introduction

Allodynia is a type of neuropathic pain defined as pain due to a stimulus which does not normally provoke pain. There is little research and conflicting advice. The purpose of this thesis is to provide a summary of the current state of hand therapy knowledge. To accomplish this, a review of the hand therapy literature related to allodynia was conducted, along with the collection of expert opinion utilizing the Delphi survey technique.

Methods

International hand therapy experts were invited to participate in a classical Delphi study. Mixed methods were used to summarize each round and inform any subsequent questioning. Thematic analysis was used to look for patterns of meaning within the written responses. A consensus level of 75% was decided upon a priori for all final recommendations.

Results

Forty-three hand therapists from 15 countries contributed to the fourth and final round. Through the consensus process definitions related to allodynia, and assessments and treatments for allodynia, were explored and recommendations generated. Two themes were identified 1) assessment and treatment decisions depend on the client's presumed underlying mechanisms contributing to the allodynia as well as psychosocial and functional status, and 2) whether the area of allodynia should be touched or not.

Discussion and conclusions

The literature and our survey results are mixed on whether it is beneficial to touch an area of allodynia. Other aspects related to allodynia such as functional or psychosocial impact are rarely addressed in the literature but were highlighted in our survey. This thesis contributes to the knowledge by presenting: 1) a summary of the current literature, 2) a new consensus definition of hypersensitivity, 3) experts' recommendations for assessment and treatment of allodynia of the hand and factors to consider when utilizing these, and 4) recommendations for future research, practice, and education.

Acknowledgements

I wish to express my sincere appreciation to my supervisor Dr. Tara L. Packham. Her dedication to learning, helping those in pain, and moving the field of hand therapy forward is inspiring and was partly what influenced me to return to university to complete this degree. Her mentorship, guidance, and positivity has been greatly appreciated. I would also like to thank my committee members Dr. Jocelyn Harris and Dr. Joy C. MacDermid for their guidance and support. All of you are inspiring and wonderful role models, as well as patient editors!

Thank you also to the many therapists who contributed to this research. Finding time in their busy schedules during the pandemic to share their knowledge and expertise made this work possible.

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Abbreviations and Symbols

Aβ – A beta (mechanoreceptive afferent neuron)

Aδ – A delta (nociceptive afferent neuron)

AROM – active range of motion

C – C (nociceptive afferent neuron)

CI – confidence interval

CRPS – complex regional pain syndrome

DASH – Disabilities of the Arm Shoulder and Hand

GMI – graded motor imagery

Hz – Hertz (cycles per second)

IASP – International Association for the Study of Pain

ICC – intra-class correlation coefficient

MPQ – McGill Pain Questionnaire

n – number of participants

NRS – numeric rating scale

p – statistical symbol representing the probability threshold for significance

PROM – passive range of motion

PRWHE – Patient-Rated Wrist/Hand Evaluation

QDSA – Questionnaire Douleur St. Antoine (French version of the McGill Pain Questionnaire)

QST – quantitative sensory testing

ROM – range of motion

RPS – Rainbow pain scale

S1 – primary somatosensory cortex

S2 – secondary somatosensory cortex

SRM – Somatosensory Rehabilitation of Pain Method

VAS – visual analogue scale

Appendices

Declaration of Academic Achievement

I, Andrea Hebert declare this thesis to be my own work. The idea for this research was generated through discussion with my supervisor Dr. Tara L. Packham. I conducted the literature review independently. I was primarily responsible for the creation of each of the surveys, data collection, and data analysis, with guidance and input from my supervisor at all stages. Dr. Packham also assisted with study design, study recruitment, and thesis revisions. Committee members Dr. Jocelyn Harris and Dr. Joy C. MacDermid assisted with the initial scope and purpose of the study, provided input during committee meetings, and contributed to thesis revisions. This thesis is in partial fulfilment of the requirements for the degree Master of Science, Rehabilitation Science.

Chapter 1. Introduction and Literature Review

The usual mechanism for pain sensation following trauma involves the activation of nociceptive neurons. (Elliott & Barbe, 2021) A nociceptive signal is transmitted to the spinal cord, then to numerous areas in the brain where it is interpreted and perceived as pain. (Elliott & Barbe, 2021) In contrast, neuropathic pain is caused by a lesion or disease of parts of the nervous system that usually signal somatosensory information. (T. Jensen & Finnerup, 2014) In neuropathic pain, changes in the nervous system mean pain can occur without activation of nociceptive neurons or can occur with stimulation much below the usual level that would cause pain. (Elliott & Barbe, 2021) A common characteristic of neuropathic pain is stimulus evoked pain (T. Jensen & Finnerup, 2014) which can be divided into **hyperalgesia** (where the stimulus is painful, and the response is heightened pain) or **allodynia**. Allodynia is defined by the International Association for the Study of Pain (IASP) as “pain due to a stimulus which does not normally provoke pain”. (Merskey & Bogduk, 1994) Stimuli can be either mechanical (moving touch or pressure) or thermal (hot or cold). Experiencing pain when the hand is touched can interfere with an individual’s ability to participate in daily activities, work, therapy and can be distressing. Allodynia is a sign of both peripheral and central sensitization. (Finnerup et al., 2021) Neuropathic pain can lead to decreased health-related quality of life in individuals with a variety of conditions, (M. Jensen et al., 2007) including following upper extremity nerve injuries. (Novak & Katz, 2010)

Neuropathic Pain in Hand Therapy

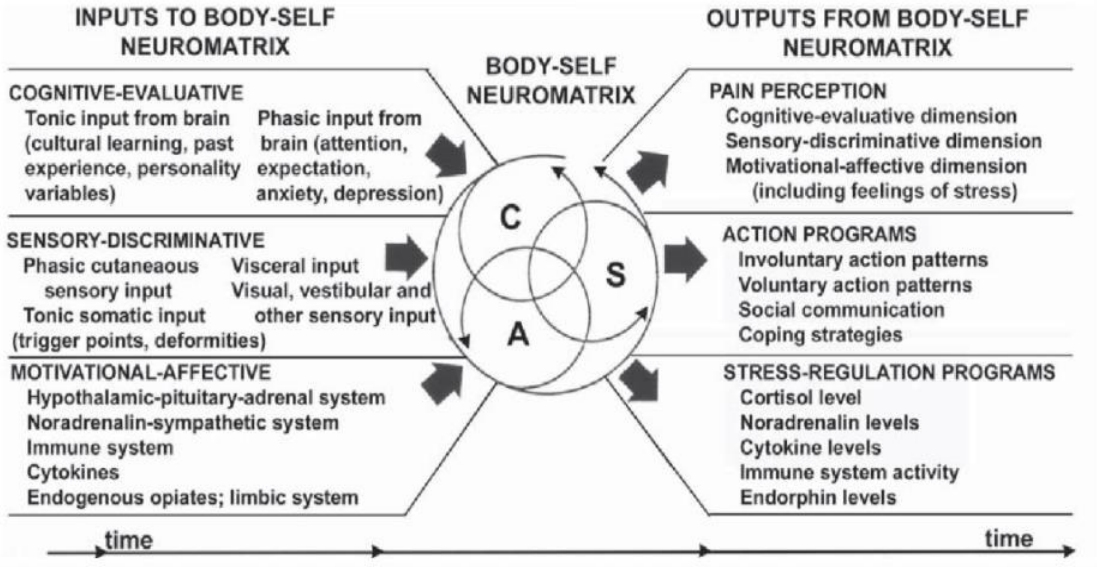
The prevalence of allodynia reported depends on the criteria and methods used to assess thus, it varies widely across studies with different diagnostic groups.(T. Jensen & Finnerup, 2014) Allodynia can be associated with almost any chronic pain condition (for example fibromyalgia, and osteoarthritis) as well as central and peripheral neurological conditions. It is a common symptom seen in neuropathic pain conditions affecting 15 to 50% of individuals with neuropathic pain.(T. Jensen & Finnerup, 2014) Neuropathic pain can be from a variety of peripheral conditions (e.g., nerve injury, complex regional pain syndrome (CRPS) post injury, amputation, post herpetic neuralgia, diabetic neuropathy) or central conditions (e.g., spinal cord injury, stroke, multiple sclerosis). Several studies have assessed the sensory profiles of individuals with CRPS and have reported between 24% to 54% experience allodynia. (Birklein et al., 2000; Dietz et al., 2019; Gierthmühlen et al., 2012)

Pain is not just a physical / sensory experience as was once believed. Biopsychosocial models of pain have been developed to help explain many of the factors contributing to an experience of pain. The Neuromatrix Model of Pain (Melzack, 2001) is a biopsychosocial model that acknowledges the inputs of cognitive / evaluative, sensory / discriminative, and motivational / affective factors in the experience of pain. This model also outlines outputs including pain perception, behavioural responses, and stress regulation. Pain itself is a stressor and can perpetuate the state. Everyone’s distinct neuromatrix determines how

pain is interpreted and experienced. This model is useful as it provides a way of looking at pain that involves not just the contributing factors (“inputs”) to pain but also how the individual responds (“outputs”) as presented in figure 1.

Figure 1

Neuromatrix Model of Pain



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Terms and Definitions Related to Allodynia

The IASP convened a task on pain terminology in 1994 (Merskey & Bogduk, 1994) with many definitions, including the definition of allodynia, updated in 2012, (Merskey & Bogduk, 2012) and the definition of pain updated in 2020. (Raja et al., 2020) IASP definitions relevant to this thesis are:

- Allodynia – “pain due to a stimulus that does not normally provoke pain”
- Dysesthesia – “an unpleasant abnormal sensation, whether spontaneous or evoked” (allodynia and hyperalgesia are considered special cases of dysesthesia)
- Hyperalgesia – “increased pain from a stimulus that normally provokes pain”
- Hyperesthesia – “Increased sensitivity to stimulation, excluding the special senses.” (Note – “Hyperesthesia may refer to various modes of cutaneous sensibility including touch and thermal sensation without pain, as well as to pain”, Note – “Hyperesthesia includes both allodynia and hyperalgesia, but the more specific terms should be used wherever they are applicable”)
- Neuropathic pain – “Pain caused by a lesion or disease of the somatosensory nervous system”
- Pain – “An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage.”
- Sensitization – “Increased responsiveness of nociceptive neurons to their normal input, and/or recruitment of a response to normally subthreshold

inputs" (note - "Clinically, sensitization may only be inferred indirectly from phenomena such as hyperalgesia or allodynia")

The original IASP definition of allodynia (Merskey & Bogduk, 1994) included the wording "to normal skin" but was later changed (Merskey & Bogduk, 2012) to remove any suggestion that allodynia applied only to referred pain. The original definition also referred to the stimulus as "non noxious" which was removed as the stimulus may be noxious sometimes and not at other times, also noxious is hard to delimit. Definitions of allodynia found in research papers are not always consistent with the IASP definition. For example, it has been defined as *"…pain at perception thresholds that were non-noxious in the intact contralateral limb or in control subjects"* (Htut et al., 2006, p. 597) or *"the perception of innocuous stimuli as painful".* (Love-Jones et al., 2009, p. 942)

Central sensitization has been written about extensively by Woolf. (Latremoliere & Woolf, 2009; Woolf, 2011, 2018) The term central sensitization was initially used to describe changes at the spinal cord level. Now it is used to encompass all of the central nervous system, i.e., spinal cord, brainstem and cortex and reflects centrally mediated amplification of pain with numerous mechanisms contributing to it. (Woolf, 2018)

The term hypersensitivity is not formally defined by the IASP. However, it is a term commonly used in practice and found in articles and hand therapy textbooks. For example, in the commonly used hand therapy reference volumes

Rehabilitation of the Hand and Upper Extremity (Skirven et al., 2021) the chapter on sensory relearning uses the terms oversensitivity, hypersensitive and hypersensitivity along with allodynia and hyperesthesia when discussing desensitization. (Rosen et al., 2021) A 1983 hand therapy article defined hypersensitivity as *"a condition of extreme discomfort or irritability in response to normally non noxious tactile stimulation"* (Yerxa et al., 1983, p. 176). The medical definition of hypersensitivity (Merriam-Webster Dictionary, 2021b) is 1) excessively or abnormally sensitive, and 2) abnormally susceptible physiologically to a specific agent (as a drug or antigen).

The clear and consistent use of terminology is important to research and practice. Although much progress has been made by the IASP in defining pain related terms, there are still terms which are not used consistently, or not defined at all.

Mechanisms of Allodynia

The types of nerve fibres involved in allodynia, how they interact in the spinal cord, and the cortical changes seen during allodynia are complex and our understanding is evolving. The cause of mechanical allodynia is not fully understood, it is a composite of both peripheral and central nervous system changes. (Finnerup et al., 2021) Peripheral nervous system changes are thought to be a key driver of the condition.(Devor, 2013; Lolignier et al., 2015) Following tissue injury, tissues and immune cells release mediators causing local inflammation. (Elliott & Barbe, 2021) These mediators sensitize nociceptors

through changes to ion channels causing the nociceptors to have a lowered threshold for stimulation and activity which is termed peripheral sensitization. (Elliott & Barbe, 2021; Woolf, 2018) These sensitized nociceptors provide a barrage of information to the dorsal horn of the spinal cord. This increase in nociceptor input induces excitability in nociceptive fibres in the spinal cord contributing to central sensitization. (Devor, 2013) This increase in excitability allows peripheral inputs from mechanosensitive afferents (Aβ) fibres, which carry information about touch, to engage with nociceptive pathways thus turning touch sensations into pain. (Finnerup et al., 2021) Nerve blocks that selectively block Aβ fibres resolve dynamic mechanical allodynia while the block is in effect,(Devor, 2013; T. Jensen & Finnerup, 2014; La & Chung, 2017) although the effect for static mechanical allodynia is not as consistent. (La & Chung, 2017) The exact mechanism of how large mechanoreceptive Aβ fibre input gains access to the nociceptive pathways in central sensitization is unclear, but may involve (Finnerup et al., 2021)

- sprouting of Aβ fibres into lamina II of the spinal cord
- phenotypic switch of Aβ fibres (release of substance P)
- disinhibition of pre-existing pathways
- loss of inhibition from low threshold mechanoreceptive C tactile afferents
- disrupted chloride-mediated spinal inhibition
- disturbed supraspinal coding of the balance between altered Aβ fibre firing frequency and nociceptive input

Injury to the peripheral nerves themselves can also initiate central sensitization through similar processes. (Woolf, 2018) Structural and functional changes to peripheral nerves occur following injury including changes to ion channels, membrane receptors, and transducer molecules. (Devor, 2013) These changes may occur at many locations including at the end of an injured nerve, in areas of demyelination, in regenerating collateral sprouts, the dorsal root ganglion and in neighbouring nerves. (Devor, 2013; Finnerup et al., 2021) These changes cause ectopic firing of nerves contributing to abnormal responses to mechanical and thermal stimuli contributing to allodynia. (T. Jensen & Finnerup, 2014)

Allodynia can be evoked by mechanical or thermal stimuli. Mechanical stimuli may be static (also called ‘blunt’ or ‘punctate’) or dynamic (i.e., moving). Thermal stimuli may be hot or cold. Different nerve fibres broadly grouped as nociceptors (Aδ and C) or mechanoreceptors (Aβ) carry these sensations. (T. Jensen & Finnerup, 2014) The role of these types of nerve fibres is summarized in table 1. Within the dorsal horn of the spinal cord different types of neurons are activated in mechanical allodynia depending on the nature of the injury (whether inflammatory or neuropathic). (Peirs et al., 2021)

Descending pathways from supraspinal structures to the spinal cord dorsal horn have a direct impact, both facilitatory and inhibitory, on nociceptive neurons. (Chen & Heinricher, 2019) Three descending pathways through which

supraspinal structures may influence nociceptive transmission have been recently described. (Finnerup et al., 2021) Their specific influence on allodynia is not yet known. Research shows changes in areas of activation within the brain in individuals experiencing allodynia. (Geha et al., 2008; Peyron et al., 2004, 2013) In individuals with CRPS the extent of allodynia was found to correlate with the degree of parietal lobe dysfunction. (Cohen et al., 2013) Despite some limitations due to sample size and heterogeneous aetiologies of pain, brain imaging studies of mechanical allodynia have consistently found it was associated with increased activation in the main components of the lateral pain system (S1, S2 and lateral thalamus) and prefrontal cortex. (Gilron et al., 2011) However, studies showing that central sensitization can independently generate neuropathic pain are elusive. (Meacham et al., 2017) Once peripheral drive is brought under control the central sensitization and resulting allodynia resolves. (Devor, 2013) According to Woolf, the amount of peripheral input needed to maintain the central sensitization decreases over time, and in some individuals the condition can become autonomous and not need peripheral input, but the mechanisms behind this are not well understood. (Woolf, 2018) Other authors however emphasize the importance of peripheral input to maintain central sensitization with the understanding that central sensitization acts rather as an amplifier of peripheral signals and is not an independent generator of pain. (Meacham et al., 2017)

In summary, allodynia is driven by both peripheral and central mechanisms. (Finnerup et al., 2021) It has been shown to be associated with Aβ

mechanoreceptive nerve fibres connecting to nociceptive pathways in the spinal cord, turning touch into pain. When an individual is experiencing allodynia altered cortical responses are observed but it is unclear if this is a response to the peripheral input or if it may also, to some degree, drive the condition.

Assessment of Allodynia

Assessment for the presence of different types of allodynia can be done in the clinic (T. Jensen & Finnerup, 2014) with simple tools or in a lab with more specialized equipment. Simple assessment approaches are described in table 1.

Table 1

Allodynia Types, Common Assessment, and Nerve Fibres Involved

Type of allodynia	**Common approaches to assessment in the clinic**	**Nerve fibres involved**
Dynamic mechanical	Light stroking with a cotton bud / ball, painter's brush	Primarily Aβ and possibly C tactile
Static mechanical (superficial)	Gentle finger pressure applied to the skin Graded monofilaments	Aδ and C Aβ (see text)
Static mechanical (deep)	Gentle finger pressure applied to the skin and underlying tissue	Aδ and C
Punctate	Prick with stick / pin, or monofilament	Mostly Aδ and some C
Thermal - cold	Cold glass or metal object, thermoroller at 20° Celsius	Aδ and C
Thermal - heat	Warm glass or metal object, thermoroller at 40° Celsius	Aδ and C

Standardization of assessment via these common methods is challenging due to the difficulty modulating the pressure, speed and size of the area stimulated. Lower brushing velocity and higher force have been found to be associated with increased pain. (Samuelsson et al., 2011) Thus, while helpful as a quick clinical screening to determine if allodynia is present or absent, these methods are not suited for monitoring degrees of change or for research. Quantitative sensory testing (Rolke, Baron, et al., 2006) (QST) is a lab-based method of standardizing sensory assessment including assessment of mechanical and thermal allodynia and is often used in research but not clinical practice. Allodynia can also be assessed for and quantified using an algometer which can reliably measure pressure pain threshold. (Kinser et al., 2009) However, this type of equipment is not available in most hand therapy clinics. An approach to standardize the pressure applied in the assessment of static mechanical allodynia which uses equipment accessible to clinicians is the Rainbow Pain Scale (RPS).(Packham et al., 2019) This assessment uses seven graded monofilaments from the Semmes Weinstein monofilament set to categorize the severity of the allodynia. Evidence suggests (Packham et al., 2019) at least moderate test-retest reliability (intra-class correlation coefficient (ICC) 0.87 n=28, $p< 0.001$) and inter-rater reliability (ICC 0.78, n=31, $p<0.001$) of this assessment approach.

There is no established best practice on how to assess for and record the location and size of an area of allodynia. Allodynography (Packham et al., 2020)

is a technique used as part of the Somatosensory Rehabilitation of Pain Method (SRM). (Spicher, Barquet, et al., 2020) In this method allodynia is defined as a painful response (3 of 10 on a numeric rating scale or 30 mm on a 100-mm visual analogue scale) to a single touch with a 15-g stimulus (Semmes Weinstein filament #5.18). This definition of pain is used to systematically map out the area of allodynia. Preliminary evidence with small sample sizes shows excellent inter-rater reliability (ICC 0.97, n=12, p<0.001) and test-retest reliability (ICC, 0.89 n=10, p<0.001) of this approach. (Packham et al., 2020).

As allodynia is a type of neuropathic pain, assessments for neuropathic pain in general may be helpful**.** There are many self reported assessments for neuropathic pain. The Radboud Evaluation of Sensitivity (Packham, MacDermid, et al., 2018) is the only one that is specific to hand sensitivity. In this test, the individual rates how different the affected hand feels compared to the unaffected hand at rest, with movement and with 6 specific stimuli (e.g., touching hair, clothes, rice etc.). It does not specifically assess pain or allodynia. This assessment was developed in the Netherlands to evaluate sensitivity in individuals with CRPS. It has been translated and culturally validated for use in North America. (Packham, MacDermid, et al., 2018) Other self report assessments for neuropathic pain that are not specific to the hand or allodynia may be helpful. Aspects of these self reports may capture symptoms of allodynia and are described in table 2.

Table 2

Allodynia Assessment Within Self-Report Questionnaires for Neuropathic Pain

Self reported assessment of neuropathic pain	Number of pain related questions	Number of allodynia related questions	Allodynia related questions
Revised version of the short form McGill Pain Questionnaire (Dworkin et al., 2009)	22	1	"pain caused by light touch"
Self-report version of the Leeds Assessment of Neuropathic Signs and Symptoms (Bennett et al., 2005)	7	3 (all three questions may capture either allodynia or non-painful hyperesthesia)	"Does your pain make your skin abnormally sensitive to touch? Getting unpleasant sensations or pain when lightly stroking the skin might describe this" Following rubbing the area: "I feel discomfort in the area like pins and needles, tingling or burning in the painful area that is different from the non-painful area" Following pressing the area: "I feel numbness or tenderness in the painful area that is different from the non-painful area"
Neuropathic Pain Questionnaire (Krause & Backonja, 2003)	12	2 (question one may capture non-painful hyperesthesia)	"overly sensitive to touch" "increased pain due to touch"
painDETECT questionnaire (Freynhagen et al., 2006)	9	2	"Is light touching (clothing, a blanket) in this area painful?" "Does slight pressure in this area, e.g., with a finger, trigger pain?"
Neuropathic Pain Symptom Inventory (Bouhassira et al., 2004)	12	3	"Is your pain provoked or increased by brushing on the painful area?"

			"Is your pain provoked or increased by pressure on the painful area?" "Is your pain provoked or increased by contact with something cold on the painful area?"

Two neuropathic pain conditions seen frequently in hand therapy (Keller et al., 2016) which may present with allodynia are peripheral nerve injuries and CRPS. A systematic review (Jerosch-Herold, 2005) of evidence for validity, reliability, and responsiveness of tests for sensibility following peripheral nerve injuries found 15 studies investigating the psychometric properties of hand sensibility tests. Of the 15 studies included in the review 4 evaluated pain and none used the term allodynia. Three of the papers were by Rosén (Rosén, 1996; Rosén et al., 2000; Rosén & Lundborg, 2000) who developed a summary score for functional outcome following peripheral nerve repair. Factor analysis (Rosén & Lundborg, 2000) demonstrated three domains i.e., sensory function, motor function, and pain/discomfort (cold intolerance and hyperesthesia). The component of hyperesthesia in this assessment is rated on a 4-point scale (0 to 3, with 0 = hinders function, and 3 = none / minor). The individual is asked to estimate their perceived problems with pain or discomfort with normal touch. There is no stimulus applied in this evaluation. Similarly, there is little guidance on how to assess for allodynia when it is part of the presentation of CRPS. A core outcome set for CRPS research (Grieve et al., 2017) has been established and

includes measures of pain but allodynia is not specifically addressed. The Budapest criteria (Harden et al., 2010) for diagnosis of CRPS includes assessment for signs of allodynia described as response to light touch and/or deep somatic pressure and/or joint movement, or symptoms i.e., a subjective report of allodynia, although a standardized approach to these is not described. The CRPS severity score (Harden et al., 2017) includes assessment of allodynia signs, described in supplemental online material, as: “Allodynia: to light touch as tested by light manual touch (or brush); to deep joint pressure, as assessed by ‘firm’ manual pressure to joint; to vibration as assessed by 128 Hz tuning fork over bony prominence in affected limb; to temperature as assessed by the blade of a tuning fork cooled under cold water (or cool water in a test tube) and heated under warm water (or warm water in a test tube). Allodynia reflects normally innocuous stimuli now being interpreted as painful.”

To evaluate the extent of hand therapy literature on mechanical allodynia assessment and treatment a limited search was conducted in PubMed in October 2021. Primary intervention studies for mechanical allodynia were searched for using the terms allodyni*, hypersensiti* and dysesthesia in the Journal of Hand Therapy. Hypersensitivity and dysesthesia were included as authors may use these terms to measure pain due to touch i.e., allodynia. The search produced 11 results after 1 duplicate was removed. There was one systematic review of tactile stimulation intervention studies for dysesthesia (Quintal et al., 2021) and three primary intervention studies on allodynia. (Packham, Spicher, et al., 2018; Quintal

et al., 2018; Sweeney & Harms, 1996) (two of which were included in the review). The remaining 7 articles were excluded as they were related to cold hypersensitivity (2) or were not intervention studies (5). Table 3 presents the 9 English articles that assessed for allodynia intensity or location found in the systematic review (which are from a variety of journals) plus the one article (Sweeney & Harms, 1996) found in the search that was not included in the review. As neuropathic pain may also impact physical, emotional, and social functioning, quality of sleep and overall quality of life (M. Jensen et al., 2007) included studies were reviewed to see if they were also assessing for any of these concerns.

Table 3

Rehabilitation Studies Assessing Allodynia

Study	**Intervention**	**Allodynia intensity**	**How allodynic area was determined**	**Other outcome measures used**
Menck (Menck et al., 2000) Case study **CRPS** Hand and upper extremity	Desensitization portion of program: **touching area with textures and massage** 5x/day – program graded Edema control, exercise initially. Joint manipulation of the T3 and T4 spinal segments	**Response to light touch** and pinwheel – present or absent	Described in words	Impact on function, sleep and emotional state described (no standardized assessments)
Love-Jones (Love-Jones et al., 2009) n = 20	Contralateral side stroked, then rest. Most painful spot **stroked** with a	NRS rating in **response to stroking** with a	Standardized 2cm grid marked on the skin – area identified	

allodynia in a mixed neuropathic pain population mixed locations	cotton bud 2 -3 cm /s, 10x in 1 minute	cotton bud on most painful spot	and mapped by brushing with a cotton bud 2-3cm /s towards allodynic area	
Goransson (Göransson & Cederlund, 2011) n = 39 **hyperesthesia** on / near an upper extremity scar (included if pain decreased after a few minutes of massage)	**Massage** with barely tolerated texture 2 - 5 minutes until area numb 3x / day Textures graded	**VAS rating with use or touch**	Client drawn on a map – area calculated in mm^2	Canadian Occupational Performance Measure
Lewis (Lewis et al., 2011) n = 4 **CRPS** 2 upper extremity	Textures **placed or stroked** on contralateral then allodynic area with attention to the stimulus quality. 1–5 minutes 6-8 x/day	NRS rating immediately post **placing or stroking** a stimulus used in assessment to select textures	Standardized 2cm grid marked on the skin – painful area identified and mapped by stroking with a cotton bud	-Brief Pain Inventory -Bath Body Perception Disturbance Scale -2-point discrimination on allodynic area
Sweeney (Sweeney & Harms, 1996) n = 29 **allodynia** post amputation or scars	Self mobilization home program for neural tension	VAS rating in response to therapist applied **light touch (cotton wool), deep pressure (blunt end of pencil) and pin prick**	Client described	-ROM -Upper limb tension test
Packham (Packham, Spicher, et al., 2018) n = 48 **CRPS**	Somatosensory Rehabilitation of Pain Method	Rainbow pain scale (7 graded **monofilaments**). First filament to elicit pain noted.	Allodynography; area mapped with a 15 g monofilament and recorded on a grid. Area calculated in cm^2	QDSA (French version of the McGill Pain Questionnaire) 2-point discrimination. Pressure and vibration perception thresholds.

Nedelec (Nedelec et al., 2016) n = 15 **Burns**	Somatosensory Rehabilitation of Pain Method	Rainbow Pain Scale (7 graded **monofilaments**). First filament to elicit pain noted.	Allodynography; area mapped with a 15 g monofilament and traced then quantified electronically	QDSA (French version of the McGill Pain Questionnaire)
Spicher (Spicher et al., 2008) n = 43 **neuropathic pain** (8 brachial)	Somatosensory Rehabilitation of Pain Method	Rainbow Pain Scale (7 graded **monofilaments**). First filament to elicit pain noted.	Allodynography; area mapped with a 15 g monofilament and recorded on a grid. Area calculated in cm^2	Pressure perception threshold
Quintal (Quintal et al., 2018) case study **CRPS**	Somatosensory Rehabilitation of Pain Method and Graded Motor Imagery initially	Rainbow Pain Scale (7 graded **monofilaments**). First filament to elicit pain noted.	Allodynography; area mapped with a 15 g monofilament and recorded on a grid. Area calculated in cm^2	QDSA, NRS, VAS, ROM, strength, 2-point discrimination, Canadian French version of the DASH Laterality recognition

Key: CRPS = complex regional pain syndrome, NRS = numeric rating scale, VAS = visual analogue scale, ROM = range of motion, QDSA = Questionnaire de la Douleur Saint-Antoine (French version of the McGill Pain Questionnaire), DASH = Disabilities of the Arm Shoulder and Hand.

In summary, assessments for allodynia range from dichotomous ratings of present / absent to more detailed mapping and quantification. Lab based QST, while providing standardization of assessment, is not accessible to clinicians. While there are clearer recommendations for clinicians regarding assessment contained within the SRM approach, at present there are barriers to implementation. A 35-hour training course is required to become certified in the method, and the primary textbook has only been published in English once, while several newer French editions exist, reflecting the evolution of this emerging

technique. Also, there is little attention to the assessment of emotional and functional impacts of allodynia in research papers.

Treatment of Allodynia

Information on how to treat allodynia found in hand therapy textbooks is limited and the suggested approaches are not consistent. In the 6th edition of the text *Rehabilitation of the Hand and Upper Extremity*, the chapter on pain management (Fedorczyk, 2011) describes allodynia as centrally mediated and states common interventions are usually ineffective and recommends pharmacologic agents and behavior modification. In the same edition the chapter on CRPS management (Walsh, 2011) suggests allodynia treatment should include desensitization using textures, percussion, pressure, or vibration with each modality used until sensory accommodation is reached and, if desensitization fails orthotics, inserts or gloves can be used to allow function. In the 2021 version of this text, again there is a difference of approach noted. The chapter on sensory relearning (Rosen et al., 2021) suggests desensitization for allodynia with the painful area of the hand being touched and stimulated to gradually reduce oversensitivity. The chapter on CRPS management (Packham & Holly, 2021) suggests direct desensitization may help when allodynia is due to peripheral sensitization but should be avoided when allodynia and summation are suggestive of central sensitization. In another text, Cooper's *Fundamentals of Hand Therapy*, (Stralka, 2020) desensitization for CRPS is recommended to start outside the painful area using textures, vibration, pressure, or percussion, and

slowly progress into the painful area with constant attention to potential increase in symptoms.

Clinical practice guidelines have little to offer on how to treat allodynia. There are no guidelines specific to allodynia. As allodynia is commonly associated with CRPS these guidelines were reviewed. Rehabilitation treatment of allodynia is not specifically mentioned in most guidelines for CRPS (Goebel et al., 2019; Perez et al., 2010; Turner-Stokes & Goebel, 2011) or in an international survey of clinical practice. (Grieve et al., 2019) CRPS guidelines in the UK (Goebel et al., 2018) reference one study which used mirror therapy and desensitization (C. McCabe & Blake, 2008) for “conflict allodynia” and, in reference to allodynia post amputation stated sometimes allodynia can be alleviated with medicated plasters or other technologies. This guideline provides guidance for “desensitization” as an appendix (Goebel et al., 2018) however there are conflicting statements regarding touching the painful area. Another guideline (Harden et al., 2013) discusses the importance of active use of a limb and psychological interventions to reduce stress hormones / catecholamines (which may reduce activation of nociceptive drive of central sensitization and allodynia). In a 2016 Cochrane review (Smart et al., 2016) of physiotherapy for pain and disability in adults with CRPS, 18 trials were included; two of which (Cacchio, de Blasis, de Blasis, et al., 2009; Cacchio, de Blasis, Necozione, et al., 2009) used brush evoked allodynia as an outcome measure (one primary, one secondary) for interventions of mirror therapy or mental imagery following stroke.

Individual studies were looked at to see how allodynia is being treated in research and are outlined in table 3. In a recent review (Quintal et al., 2021) of tactile stimulation programs for dysesthesia following nerve injury the authors concluded there is inconclusive evidence, inconsistent implementation and the studies included were of low to very low quality. Although neuropathic pain has been associated with reduced quality of life, poor sleep, and altered emotional and social functioning, (M. Jensen et al., 2007) no hand rehabilitation research was found on these areas specifically related to allodynia.

Tactile Stimulation as a Treatment for Allodynia

Approaches to tactile stimulation can be looked at by where the stimulation is applied in relation to the area of allodynia, the type of stimulus used, grading of the stimulus, and the amount of attention / discrimination needed for the task. The stimulus may be applied a) directly on the area of allodynia, (Rosen et al., 2021) b) just outside the area but not on it and gradually moved in, (Stralka, 2020) or c) in an area more distant but anatomically related through the nervous system. (Spicher, Barquet, et al., 2020) The stimulus may be of various textures or particles, vibration, or temperatures, which are often graded from soft / most tolerable to rough / least tolerable. (Rosen et al., 2021) The amount of attention needed for the task, if it is done by looking at the limb, looking at a reflection of the unaffected limb in a mirror, (C. McCabe, 2011) or with the requirement to determine the location or quality of the stimulus (Moseley et al., 2008) (e.g.,

rough vs. soft or large vs. small) are also variables that can be manipulated during sensory stimulation.

Applying a tactile stimulus directly on an area of allodynia is often referred to as “desensitization”. (Packham, 2021; Yerxa et al., 1983) This approach utilizes various textures and / or particles applied to the painful area and includes immersion techniques such as placing the hand in rice or beans or fluidotherapy for direct stimulation of the painful area. (Rosen et al., 2021) The treatment is often graded starting with the most tolerable stimulus (although it is still painful). Starting with the least painful area and progressing distally as tolerated may be recommended. (Lewis et al., 2011) Direct touching on an area of allodynia is thought to be effective by flooding the area with intense stimuli to allow for “sensory accommodation”. (Wietlisbach, 2020) The theory to explain how “sensory accommodation” is achieved is unclear. One study (Love-Jones et al., 2009) of direct brushing stimulation on an area of allodynia in a mixed neuropathic pain population hypothesized a mechanism of action for desensitization on a painful area based on their findings. In this study the allodynic area was found to decrease by >30% in 9 out of 18 participants (none increased >30%), and the shrinkage could persist to the next day for some participants. However, the intensity of the pain did not change. The authors posit that in addition to Aβ fibres contributing to allodynia, in some individuals some Aβ fibres may also engage in segmental inhibitory activity producing an effect that narrows the size of the afferent field from which allodynia can be provoked. In

another study of desensitization by direct touch to the painful area, (Lewis et al., 2007) some individuals reported desensitization helped them perceive their limb more normally, while others expressed difficulty tolerating direct stimulation.

Tactile stimulation can also be done outside / adjacent to the area of allodynia. Although this may also be referred to as “desensitization” (Stralka, 2020) it is distinctly different from touching on an area of allodynia as it is not painful, and the Aβ fibres that are stimulated are not connecting to nociceptive pathways in the spinal cord. Often this approach is recommended with the goal of slowly progressing into the painful area. (Stralka, 2020) The use of the term “desensitization” to refer to both touching a painful area, and touching a non-painful adjacent area lacks clarity and precision.

Desensitization may be part of a sensory relearning program for peripheral nerve disorders. In an online survey (Jerosch-Herold, 2011) of 70 European hand therapists, 83.9% reported desensitization (through immersing the hand in different textures) was part of their current sensory relearning programs. 79.9% of participants indicated sensory relearning should be used for individuals with hypersensitivity (including hyperesthesia and allodynia), although only 6.8% indicated sensory relearning should be used for patients who experience problems in daily living, phantom pain or sensations, or CRPS. The author suggests “desensitization can be considered as a form of relearning to interpret sensory stimuli as non-noxious (p.294).” (Jerosch-Herold, 2011) Although the research on sensory discrimination training has not specifically addressed

allodynia it may be worth considering in the context of touching directly on an area of allodynia. In a study (Moseley et al., 2008) of 13 individuals with CRPS it was found that discriminating the diameter and location of stimuli applied within the area of pain (but the stimulation was “not painful”) reduced pain (measured on a VAS) and improved two-point discrimination compared to stimulation alone, which had no effect.

Applying a stimulus in an area distant from the allodynia is used within SRM. (Spicher, Barquet, et al., 2020) In this approach the therapist first hypothesizes which cutaneous nerve branch is affected. (Spicher, Packham, et al., 2020) Then, a comfortable tactile stimulation is applied to an area with normal sensation in an associated cutaneous nerve branch distant from the allodynia. Stimulation is applied weekly by a therapist and 6 times daily for 1 minute by the client. Contact with the area of allodynia is avoided in therapy and strategies to reduce contact during daily tasks are reviewed with the client. (Packham, Spicher, et al., 2018) Once allodynia has abated sensory re-education for hypoesthesia is done if needed. SRM is thought be effective by 1) allowing neurotransmitters, generated from comfortable stimulation in an anatomically related nerve branch to reduce the aberrant signalling in the spinal cord and 2) by avoiding tactile stimuli to the area of allodynia in therapy and daily activities there is less input to maintain the maladaptive neuroplasticity contributing to the allodynia. (Spicher, Barquet, et al., 2020) An uncontrolled retrospective cohort study using SRM found a large effect size for reducing allodynia in 48 individuals

with CRPS. (Packham, Spicher, et al., 2018) Allodynia was also shown (Spicher et al., 2008) to resolve in 43 individuals with neuropathic pain (8 upper extremity) using this approach.

In summary, there is little, and at times conflicting, information in hand therapy textbooks, practice guidelines, or research papers to guide therapists on how to treat allodynia of the hand. Tactile stimulation approaches are the primary rehabilitation treatment suggested. These are varied in their application and suggested mechanism of action. In addition to a lack of clear guidance on where the stimulus should be applied, there is no evidence-based guidance for how long or how often tactile stimulation should be done. While there are clearer recommendations for treatment contained within the SRM approach, at present there are barriers to implementation as discussed previously.

Tactile stimulation for the treatment of allodynia meets the criteria of a complex intervention (Craig et al., 2008) as there are many interactions between components, there is variability of outcomes and there is flexibility or tailoring of the intervention permitted. The UK Medical Research Council (Craig et al., 2008) provides recommendations to assist in developing complex interventions. Interventions should be developed systematically, using the best available evidence and appropriate theory, then undergo testing using a carefully phased approach. Initially pilot studies should target each of the key uncertainties, then research can move to more in-depth evaluation. To date the research on

allodynia in the hand and upper limb has not been approached systematically: it has been disjointed with little attention to testing of theory.

The Delphi Technique

When evidence is limited, or inconclusive, the opinions of experts can be sought to help guide practice. The Delphi technique is a consensus-based method developed in the 1950s by the RAND corporation to assist with forecasting the emergence of new technologies. (Murphy et al., 1998) The Delphi technique has been modified (Crisp et al., 1997) and is now applied across a wide variety of fields including health research. (Murphy et al., 1998) In the Delphi technique, opinions of experts in a particular field are collected anonymously in a series of survey rounds. Following each round, the results are shared back to the group with further questions to help understand the group's opinions and to determine whether there is consensus within the group. Its popularity is related to the fact that it allows many individuals in diverse locations to participate (Keeney et al., 2006) and can engage diverse aspects of expertise. As it is anonymous, it avoids the situation where a specific expert may dominate the consensus process. (Keeney et al., 2006) In a review (Foth et al., 2016) of the Delphi technique in nursing education, criticisms of the Delphi technique are summarized. Some issues include questioning the reliability and validity of the technique, opportunity to discuss disagreements is lacking, the definition of "expert" is questioned, and why items are rated low is not clear.

The classical Delphi technique (Hasson et al., 2000; Rowe et al., 1991) uses a first round consisting of open-ended questions to generate ideas allowing the participants freedom in their responses. This is done to elicit a wide range of responses. This approach has been revised by some authors who provide pre-existing information generated from a literature review however this approach is open to bias. (Hasson et al., 2000) Vignettes can be used as elicitation tools in survey or qualitative research to generate data for further exploration related to perceptions, opinions, beliefs, and attitudes. (Barter & Renold, 1999) A criticism of vignettes is that they are removed from real life thus it is recommended that the people and scenario content are believable. (Finch, 1987) Vignettes can be combined with other methods in a mixed methods approach. (Barter & Renold, 1999)

Several articles provide guidance on reporting Delphi studies. (Boulkedid et al., 2011; Diamond et al., 2014; Hasson et al., 2000; Jünger et al., 2017; Keeney et al., 2006; von der Gracht, 2012) In addition, the Standards for Reporting Qualitative Research guidelines (O'Brien et al., 2014) can be used to ensure adequate reporting of the study's qualitative details. The systematic review by Diamond (Diamond et al., 2014) summarizes key methodologic criteria to be reported in the categories of study objective, participants, and process. Although specifically developed for Delphi studies in palliative care, the reporting recommendations by Junger (Jünger et al., 2017) are broadly applicable and provide guidance on 16 items related to study rationale, study planning and

design, study conduct, and reporting. Strategies used to enhance expert panel response rate and motivation have been suggested. (Gill et al., 2013; Keeney et al., 2006)

The original purpose of a Delphi study was to *"obtain the most reliable consensus of opinion of a group of experts. It attempts to achieve this by a series of intensive questionnaires interspersed with controlled opinion feedback."* (Dalkey & Helmer, 1963 *p. 458*) The method has undergone many modifications, is defined differently depending on the approach, and not all versions of the approach are interested in achieving consensus. (Hasson & Keeney, 2011) Given this variability in definition and application, establishing reliability and validity of the method is a challenge. (Foth et al., 2016; Hasson & Keeney, 2011; Keeney et al., 2011) Hasson and Keeney (Hasson & Keeney, 2011) provide an in-depth discussion of the reliability and validity challenges of the Delphi technique.

There is debate as to whether the Delphi method is reliable (Keeney et al., 2011) and there is a lack of evidence for the reliability of the technique. (Hasson et al., 2000) Some authors suggest the Delphi method is thought to improve reliability by avoiding meeting face to face (thus reducing group bias) and through larger numbers of participants contributing. (Hasson & Keeney, 2011; Keeney et al., 2011) However, this is debated with some authors suggesting a larger sample adds variation and thus decreases accuracy and generalizability. (Hasson & Keeney, 2011) If the same questions were posed to another panel of experts

there is no guarantee that the same conclusions would be drawn. When selecting the Delphi method in research to improve clinical practice, it is important to consider that it relies on experts to co-construct knowledge and that the outcomes are only as reliable as the available evidence and the participating experts. (Jünger et al., 2017)

Many authors agree the Delphi method provides evidence of content and face validity. (Goodman, 1987; Keeney et al., 2011; Sharkey & Sharples, 2001) Having participants who are knowledgeable, who are given ample opportunity to comment, and who are interested in the topic may help to increase the content validity of a Delphi study. (Hasson et al., 2000) Validity of the results may be affected by the response rate; loss of participants over the rounds decreases the range of opinions and can affect validity. (Sharkey & Sharples, 2001) Successive rounds can help to increase concurrent validity as successive rounds continue to compare results to previous rounds. (Hasson et al., 2000; Hasson & Keeney, 2011) As there is such a diversity of topics addressed using the Delphi method, there is no way to determine the validity of any specific definition of consensus. (Diamond et al., 2014) Given the challenges related to reliability and validity, transparency in every step towards consensus is recommended. (Foth et al., 2016)

Elements of trustworthiness (Hasson & Keeney, 2011) can be used to evaluate the rigor of qualitative research. The four elements of trustworthiness are credibility, dependability, confirmability, and transferability. (Connelly, 2016;

Hasson & Keeney, 2011) Applied to Delphi studies, credibility can be increased through iteration across the rounds, feedback to participants, member checks, and the use of other methods to confirm the findings. (Hasson & Keeney, 2011) Dependability can be increased by including a range and representative sample of experts. (Hasson & Keeney, 2011) Confirmability can be increased through a detailed description of collection and analysis processes. (Hasson & Keeney, 2011) Finally, transferability can be evaluated through verifying that the findings are applicable. (Hasson & Keeney, 2011)

The Delphi technique has the potential for both researcher and subject bias. (Hasson et al., 2000) Factors such as the researcher's level of experience, qualifications, and knowledge of the problem, can influence the reliability of reporting and thus the confidence placed in the outcome. (Hasson & Keeney, 2011) Researcher bias can be shown through setting the inclusion criteria for selecting the participants, and decisions around what items are carried to the next round. (Hasson et al., 2000) Subject bias can be shown through the agreement to participate, (Keeney et al., 2006) and level of participation which may relate to how much the outcome of the study affects them. (Hasson et al., 2000) As the composition of the panel can affect the results obtained, the potential for bias can be high. (Keeney et al., 2006)

Thesis Objectives

Allodynia is a type of neuropathic pain that can interfere with daily activities, participation in therapy, and the pain can be distressing to an individual.

Terminology related to allodynia and its treatment is not always consistent. There also is a paucity of research evidence, and conflicting recommendations to guide therapists in how to assess and treat this condition. Given this, the objectives of this thesis are to utilize the Delphi technique to 1) explore if there is support for the current definitions of allodynia and tactile hyperesthesia, 2) formulate a definition of hypersensitivity, and 3) provide guidance to therapists who treat this condition through elicitation of expert-endorsed assessment and treatment options. Finally, this thesis will bring together the literature and the Delphi findings to provide recommendations for research, clinicians and education on this topic.

Chapter 2. Study Methods

This Delphi consensus study was carried out by an interdisciplinary team with both clinical and research experience. AH is an occupational therapist and certified hand therapist with 21 years of experience in hand therapy. This work was chosen as part of her Master of Science degree as she has observed, tried, and questioned various approaches to treating allodynia in practice. TP is also an occupational therapist with 25 years of clinical experience in hand therapy. Her research has focussed on CRPS as well as allodynia. JM is a physical therapist and epidemiologist with 20 years clinical experience and a well-established research program on upper limb rehabilitation, with a particular interest in outcome measurement and knowledge translation. JH is an occupational therapist and researcher with a focus on the upper extremity in neurological conditions, and guideline development and implementation. All authors contributed to the design and analysis of the overall study however, AH and TP were the primary analysts of individual question rounds. Ethics approval was obtained through the Hamilton Integrated Research Ethics Board (study #11325).

The classical Delphi technique (Hasson et al., 2000) was used with multiple rounds of surveys anticipated, starting with open-ended questions in the first round. Participants' answers were kept anonymous from the other participants allowing for freedom of expression without pressure from other group members. Following each round, the participants were sent a new survey which

gave a summary of the previous round with questions to delve deeper into the insights, opinions, and consensus recommendations of the group.

International experts in hand therapy were e-mailed asking them to participate and nominate one or two other therapists, knowledgeable in the topic area, from their home country. Invited experts were identified using purposive sampling and had to be a) English speaking practicing occupational therapists or physical therapists, and b) with clinical expertise defined as being certified in hand therapy and/or a record of publications or presentations on the subject(s) of allodynia and/or sensitization, neuropathic pain, and/or sensory dysfunction based on an environmental scan of the literature and websites for hand therapy societies. There is no standard recommended sample size for a Delphi survey (Keeney et al., 2006); we aimed to start the survey with 50 participants to capture the breadth of hand therapy practice.

Round one was pilot tested by two hand therapy colleagues each with over 20 years of hand therapy experience. LimeSurvey software was used to conduct the survey online. A mixed methods approach, (Fetters et al., 2013) was used. The initial round was qualitative using three clinical vignettes to explore participants' definitions, and contextually situated recommendations for the evaluation and management of allodynia in hand therapy practice. Subsequent rounds used both qualitative and quantitative approaches as described in table 1 below. An iterative process was used, with data from previous rounds informing and guiding the questioning in subsequent rounds. (Hasson et al., 2000)

Table 1

Mixed Methods Approach to the Areas of Inquiry Over the Rounds

	What was requested in each round Qualitative / Quantitative			
Area of inquiry	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Definition of allodynia	Provide own definition	Vote on possible addendums		
Definition of tactile hyperesthesia	Provide own definition	Vote if agree with aspects of IASP definition comment		
Definition of hypersensitivity	Provide own definition	Select stimulus descriptor comment, if stimulus is painful or not comment, response descriptors comment, and pain experience	Select stimulus descriptor, response descriptors comment, pain experience	Vote if stimulus is noxious Vote If agree with proposed definition comment
Recommended assessment options	Provide assessment suggestions (for each vignette)	Vote on suggested items (5-point Likert scale, or "have never used") Select preferred method for pressure pain threshold testing comment Select when to use VAS or NRS and which is preferred Select when to use monofilaments to detect light touch Select typical approaches to	Vote on borderline items (yes / no) Several questions asked again to clarify location of assessment (on or avoiding area of allodynia) Overall comments	Vote on borderline items (yes / no) Vote on assessment introductory statement comment

		assessment of ROM Overall comments		
Assessment approach and clinical reasoning	Explain why assessment may be different between the 3 vignettes	Select approach to pain during assessment Explain why may deviate from selected approach	Vote if agree with assessment approach recommendations	Vote on borderline assessment approach recommendation Vote on assessment approach introductory statement comment
Recommended treatment options	Provide treatment suggestions (for each vignette)	Vote on suggested items (5-point Likert scale) or "have never used" Select if prefers to cover or not comment Select preferred description of approach to desensitizing Comment How would desensitization be different in: Presence of CRPS Peripheral vs. central drivers of pain Time since injury Neuropathic vs. nociplastic pain Presence of nerve injury	Vote on borderline items (yes / no) Several questions asked again to clarify location of treatment (on or avoiding area of allodynia) Vote if agree with provided definitions of tactile stimulation approaches Vote if agree that desensitization on the area of allodynia **is** appropriate if pain more due to peripheral drivers Vote if agree that desensitization on the area of allodynia is **not** appropriate if pain more due to central drivers Vote if agree that it is better not to cover, but covering may be	Vote on borderline items (yes / no). Added option of "it depends" for questions that were exploring if the area of allodynia should be touched or not What term best describes various tactile stimulation treatments comments Vote on borderline item desensitization and peripheral drivers of pain Vote on treatment introductory statement comment Vote on reason not to cover Vote on borderline items re when covering is acceptable

		Overall comments	appropriate in certain circumstances If prefers to not cover, select reason comment Vote if agree with circumstances when covering is acceptable Overall comments	Overall study comments
Treatment approach and clinical reasoning	Explain why treatment may be different between the 3 vignettes	Select approach to pain during treatment Explain why may deviate from selected approach	Vote if agree with treatment approach recommendations	Vote on treatment approach introductory statement comment

Key: IASP = International Association for the Study of Pain, VAS = visual analogue scale, NRS = numeric rating scale, ROM = range of motion, CRPS = complex regional pain syndrome.

Thematic analysis was used when analyzing written responses. The reflexive thematic analysis approach developed by Braun and Clarke (Braun & Clarke, 2019) was used to look for patterns of meaning within the content of written responses. An inductive, exploratory approach was used. The following six steps were used: 1) familiarization with the data, 2) coding, 3) generating initial themes, 4) revising, and developing themes, 5) refining, defining, and naming themes, and 6) writing up (Braun & Clarke, 2021) An audit trail was kept of decisions made between rounds. Coding was carried out in round one using

excel spreadsheets (described below). In subsequent rounds coding was carried out using a word document and colour coding within the comments to identify initial themes. Initial themes were used to develop questions for voting on in subsequent rounds to gauge consensus agreement.

A universally agreed upon degree of consensus does not exist for Delphi studies. (Diamond et al., 2014) We pre-defined consensus as 75% or more of participants agreeing as this is the most frequently used metric. (Diamond et al., 2014) If an item reached consensus, the result was presented in the next round informing participants that consensus was reached, and the item was added to summary tables which were iteratively populated over the course of the study. We planned to stop the survey once consensus was reached for all items or after four rounds, whichever came first.

Round One

All data collected in round one were qualitative. Demographics were collected using the standardized demographic survey questions developed by the American Society of Hand Therapists. (Stern & Packham, 2021) We solicited participants' own definitions of allodynia, tactile hyperesthesia, and hypersensitivity. We then provided three vignettes to solicit assessment and treatment suggestions. The term "painful sensitivity" was used and not "allodynia" to prevent biassing the definition questions. However, in all three cases it was clearly described that the individual experienced pain when the hand was touched i.e., allodynia. Vignettes are considered ideal for qualitative research

evaluating attitudes, perceptions, beliefs, and norms and should depict scenarios that are believable. (Finch, 1987) Thus we presented sub-acute cases of allodynia from common conditions seen in hand therapy (Keller et al., 2016) e.g., complex regional pain syndrome post distal radius fracture, post partial peripheral nerve repair, and fingertip amputation with pain throughout the finger); for the wording of each case see appendix A. As pain is recognized as a biopsychosocial experience, (Adams & Turk, 2018) our cases presented varying degrees of pain intensity, emotional response, and functional and social impact. These factors were included to offer the opportunity for biopsychosocial approaches to assessment and treatment to be put forth. Following each vignette, the participants were asked to list all assessments and treatments for "painful sensitivity" they would suggest for that case. They were also asked open ended questions about their rationale if they choose different approaches between the cases to elicit clinical reasoning, and to list any other assessments or treatments they use that were not captured by the cases.

Using excel spreadsheets participant's definitions were recorded and broken down into component parts and the use of specific words and ideas counted to generate questions for the next round. For example, in defining hypersensitivity it was recorded if a participant used the word "increased", if they stated the response was painful or not etc.

Participant's assessment and treatment suggestions were also broken down into component parts (referred to here as items) and recorded on excel

spreadsheets. Items were grouped together into categories to help organize the data. For example, mirror therapy was considered an item and put in the category of cortical representation treatments. The categories grew from the data and were not predetermined. There was overlap in where to put some items. For example, ‘massage’ could be categorized as a hands-on treatment, a sensory stimulation treatment, or an edema management treatment. Where possible, the context of the participant’s answer was used to help determine the category. For example, if the participant stated “retrograde massage” this was put in the edema management category. If the participant stated “immersion massage” this was put in the tactile stimulation category. Each item was put in only one category. Participants often recommended more than one item per category. The items from all three vignettes, plus the items that were suggested in response to the question that asked for any additional suggestions, were summarized in the spreadsheets. Items were then counted. If an item was suggested four or more times it was kept for voting on in round two. Items were dropped if they were suggested three or less times (with a few exceptions explained below).

Spreadsheets were also used to record participants’ responses to the questions regarding their rationale for different approaches to assessment and treatment. Ideas expressed in these responses were broken down into initial themes which were used to develop questions in the next round. Some ideas expressed within the answers regarding rationale needed to be looked at for deeper meaning and coding was not as obvious as for previous questions. For

example, the response "*Because there are different causes for the pain as explained above, you have to treat the pain different. With cortical changes, you need to influence the brain to change the interpretation of the peripheral nerve stimuli e.g., by Graded Motor Imagery. With changes in the sensibility of the nociceptors you have to treat the nociceptors e.g., by desensitization."* was broken down into the ideas of 1) cause of pain and 2) peripheral vs. central.

Round Two

In round two we stopped using the term "painful sensitivity" and started using the term "allodynia". We also stopped using vignettes and introduced a generic client with **"*allodynia of the hand significant enough to reduce functional use of the hand*"** as the reference point for recommendations. To help keep the focus on allodynia the introduction to round two stated; "*It was obvious from the answers to round one that the assessment and treatment of allodynia is part of, and inseparable from, the overall assessment and treatment of the hand and the individual as a whole. As a result, you will be presented with a comprehensive list of assessment and treatment options in this survey. As you move through the survey, please keep in mind the relationship between each item and allodynia of the hand*." At the start of each subsection participants were asked "*How would you assess (or treat) a client with allodynia significant enough to reduce functional use of the hand*?"

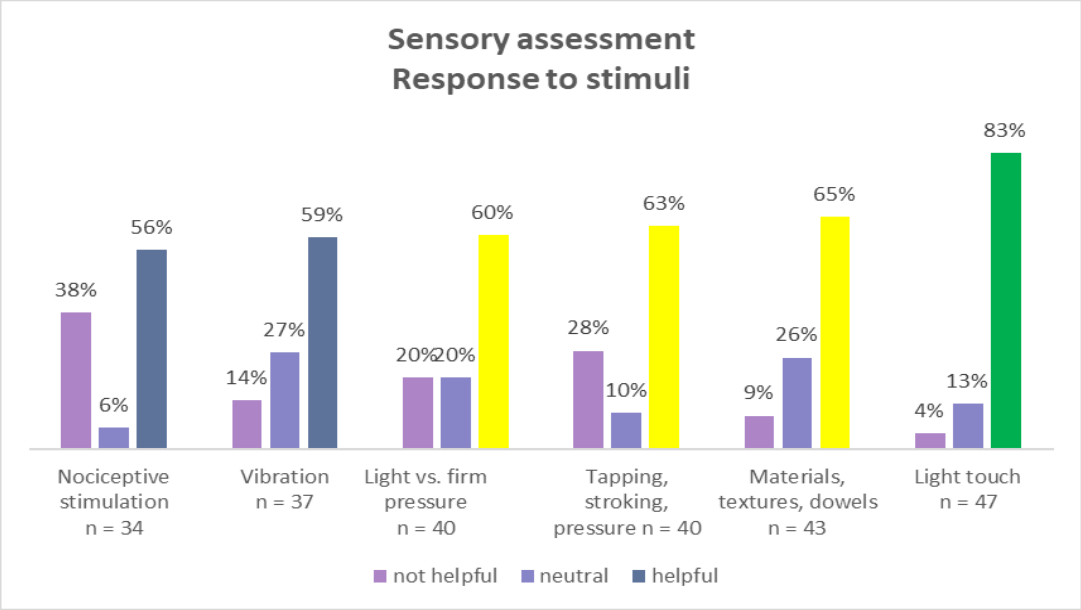
Definitions were explored in greater depth. Possible addendums to the definition of allodynia, and details of hyperesthesia were voted on. Results of

wording preferences for the definition of hypersensitivity were presented as well as exploring whether participants considered the stimulus noxious and the experience painful or not.

The suggested assessment and treatment items from round one were presented for voting. The items were presented in categories, in descending order from most to least often suggested (with a few exceptions to allow for logical order or grouping of similar items). Participants were asked to provide an opinion using 5-point Likert questions (anchored as 1 = “not helpful” to 5 = “very helpful” or 1 = “not important” to 5 = “very important”) with the option of “I have never used this” also provided. Questions were not mandatory to answer and could be skipped. Results from the Likert ratings were summarized by recoding from the 5-point scale to a 3-point categorical labelling of helpful, neutral, or not helpful. Bar graphs were created summarizing all the items in each category including the number of participants who provided an opinion, and the percent agreement. Colours were used to help identify items that had reached consensus (75% or greater agreement shown in green). We created a category of borderline consensus (60% to 74% shown in yellow) for items that were to be carried forward to the next round for further voting. If an item had less than 60% agreement, it was dropped from the survey. Figure 1 below presents an example summary graph.

Figure 1

Example Summary Graph



Some questions did not use a Likert scale but instead provided several statements for participants to choose from. The statements were generated from the suggestions in round one. Areas explored in this way were; preferred method for pressure pain threshold testing, when to use VAS or NRS and which is preferred, when to use monofilaments to detect light touch, typical approaches to assessment of ROM, whether an area of allodynia should be covered or not, preferred method of desensitization, and participants overall approach to pain during assessment and treatment. If participants indicated that they would modify their usual approach to pain during assessment or treatment we requested they explain why.

To elicit clinical reasoning about desensitization we asked the following question: “Based on the results from round one it was apparent that many participants felt they would approach desensitizing differently under different circumstances. If any of the following conditions would influence how you approach desensitizing, please indicate what you would do differently. Opportunity to comment was provide for; diagnosis of CRPS, peripheral vs. central drivers of pain, time since injury, neuropathic vs. nociplastic pain, and presence of nerve injury

Round Three

In response to participants’ comments regarding the uniqueness of each client the following was included in the survey introduction: “*Assessing and treating a hand with allodynia and associated comorbidities is complex! There are many factors that get considered and are specific to each client. This challenge was commented on by many participants in round two. Even though each client is unique there are likely some common considerations. We want to know in general - how do you approach allodynia? What do you find helpful to assess? What treatments seem to work? We would like to provide a “starting point” of recommendations for therapists to consider when they approach a client with allodynia of the hand. These recommendations would be tailored to each client as needed*.”

Given the variety of items suggested, and the complexity and possible interrelatedness of items, the following introductory statement was provided for

each subsection within the survey to help focus the responses on allodynia and its impact; "*When working with a client with allodynia of the hand significant enough to reduce functional use of the hand, what assessments would help you understand the allodynia and its impact on the client? This may include assessments that are directly or indirectly related to the allodynia. As allodynia rarely presents in isolation, there may be other areas of assessment needed. There are often relationships between constructs such as swelling affecting pain, or pain affecting movement, that may merit consideration. Many such relationships were evident in the responses to the case studies in round one. You may feel certain areas of assessment are relevant and help you understand the allodynia and its impact (e.g., assessing active movement, or the posture of the body and limb). Other areas of assessment may seem less relevant and do not help you understand the allodynia and its impact (e.g., assessing hot / cold sensation or manual muscle testing).*" These examples were selected from already accepted or dropped items to reduce potentially biasing responses towards not yet accepted items.

The definitions of allodynia and hyperesthesia were resolved after round two. Round 3 addressed the continued effort to create a definition of hypersensitivity. The focus was on whether there were important qualifiers related to the stimulus and responses. Reference definitions from the online Merriam-Webster dictionary were provided for sensitivity (Merriam-Webster Dictionary, 2021d) ("the quality or state of being sensitive as a: the capacity of an

organism or sense organ to respond to stimulation b: the quality or state of being hypersensitive") and response (Merriam-Webster Dictionary, 2021c) ("the activity or inhibition of previous activity of an organism or any of its parts resulting from stimulation"). This dictionary was chosen as it is easily accessible and free online and provides medical definitions.

In response to participants' comments regarding why they may modify their approach to assessment and / or treatment, statements related to initial themes were drafted and voted on. For the individual assessment and treatment items, following each summary graph, the items accepted and dropped after round two were listed. Participants were then asked if they would support recommending each of the remaining borderline items using a "yes / no" or "I agree / I disagree" question, as an assessment that "*may be helpful to understand the allodynia and its impact*", or a treatment that "*may be helpful to reduce the allodynia and its impact*". Questions were not mandatory to answer. Several questions were re-asked for assessments or treatments for which the location of the stimuli was not inherently clear i.e., applied within the allodynic area or outside the area.

We also explored what terminology participants use for specific tactile stimulation approaches. What participants call touching on an area of allodynia, touching near it, and touching in a distant anatomically associated nerve branch was asked. Participants were given a technique and a term to describe it and were asked if they agreed with the term. For example, they were asked if they

agreed with: "*touching directly on an area of allodynia is appropriately described by the term 'desensitization'*." The medical definition of desensitization (Merriam-Webster Dictionary, 2021a) and the definition of sensory relearning from Jerosh-Herold (Jerosch-Herold, 2011) were provided for participants to consider when responding to these questions.

To explore participants' opinions regarding whether an area of allodynia should be covered or not (with a splint, glove, wrap etc.) statements were given for voting on. Participants were asked 1) if in general they preferred not to cover an area of allodynia but would in certain circumstances, 2) if not covering is preferred to select a reason or "other reason" and comment and, 3) vote if they agreed with specific circumstances when covering is acceptable.

We also asked if participants agreed with the following statements: "If the allodynia is felt to be more due to peripheral drivers, direct desensitization on the area is appropriate" and "If the allodynia is felt to be more due to central drivers, direct desensitization on the area is not appropriate and treatments that focus on altering cortical representation of the limb are more appropriate".

Round Four

Participants were provided a proposed definition of hypersensitivity on which to vote and comment. The only aspect of this definition we had not resolved was whether participants felt the stimulus could be considered noxious. As this was the final round, we informed participants how the word noxious would

be incorporated into the definition if there was agreement that it should be part of the definition.

If an assessment or treatment item had reached borderline consensus in both rounds two and three, the threshold for borderline status was increased and only items which reached at least 70% agreement in either round two or three were kept for voting on in round four. Participants voted using a yes / no response as in round three. Several questions were posed to clarify whether the allodynic area should be touched or not during specific treatments. Based on participant feedback, for these questions a third option of "it depends" was provided i.e., "*It depends on the client, sometimes touching the area of allodynia is appropriate, sometimes it should be avoided during …*". Participants were also presented with proposed introductory statements to the assessment and treatment tables, and the assessment and treatment approach tables for voting and comment. We posed questions around covering an area of allodynia or not, and whether touching is helpful when the allodynia is felt to be more due to peripheral sensitization.

Participants were asked to select which term they would use to describe "*touching on*", "*touching next to / around but not directly on*" or "*touching in a distant anatomically associated cutaneous nerve branch*" as a treatment for allodynia. They were provided with the same answer options for each of these tactile stimulation treatment approaches.

To assess if the demographic factors of geographic location and practice experience were associated with survey final consensus results, a chi square analysis was planned with a p value set at 0.05. If consensus had not been reached for an item of interest, we planned to assess if there was a significant relationship between geographical location (categorized as Europe, North America, and other) or years of hand therapy practice (categorized as <16, 16 to 20 and >21) and support for the item. The years of practice categories were chosen to have an approximately equal number of participants in each category. An effort was made to invite approximately equal numbers of participants from the three geographical regions.

Generating initial themes and revising and developing them was done over the course of the study. The final step of refining, defining, and naming the themes was carried out following round four. Qualitative data from comments and associated initial themes, plus the quantitative data from items and statements that had reached consensus were looked at together to identify the final themes.

Study Rigor

The trustworthiness (Hasson & Keeney, 2011) of the study was considered throughout. The credibility was increased through using iteration over multiple rounds, and by providing feedback to participants and offering multiple opportunities to provide feedback on individual questions, survey sections, and the survey as a whole. (Hasson & Keeney, 2011) Dependability (Hasson & Keeney, 2011) was improved by including an international and representative

sample of hand therapy experts. Confirmability (Connelly, 2016) was increased through transparency with a detailed description of collection and analysis processes that was shared throughout the surveys. Transferability (Kuper et al., 2008) was addressed by attempting to make the findings more broadly applicable through the choice to use a generic client “with allodynia of the hand significant enough to reduce functional use of the hand” as the reference point for the recommendations. We did this as we did not want the recommendations to be condition specific. We included “reduced functional use” to denote the severity of allodynia and to differentiate it from, for example, a less limiting painful scar on the dorsum of the hand that would likely not interfere with hand use or therapy.

As Delphi studies have a high potential for bias, (Keeney et al., 2006) we tried to reduce this through multiple strategic approaches:

- Consensus agreement was set prior to the study at 75%.
- Rules were made and followed for each round. Rules were shared with the participants at the start of each survey.
- From round two on, data were presented back to participants including all dropped items and why. Items were presented in descending order of support.
- Full range of options was given with attention to not bias one direction.
- Participants were given opportunity and encouraged to comment throughout the surveys.

- Wording was applied consistently to each item. For example, “I recommend using ___ as a treatment that may help reduce the allodynia and its impact”
- To avoid biassing participants’ definitions of allodynia we avoided using this term in round one. As there was agreement on the definition of allodynia in round one, starting in round two we used the term allodynia.
- Responses were kept anonymous from the researchers (except when analyzing the fourth round, when linking data from previous surveys was needed for chi square analysis).
- Participants were reminded that it was their opinions being reflected in the results not the researchers’ opinions, the researchers were remaining impartial to the results.
- The snowball technique helped to reduce researcher bias as we did not have control over the final composition of the panel of participants. We requested nominees be practicing occupational therapists or physical therapists who were knowledgeable about allodynia.

Chapter 3: Study Results

Potential participants were contacted in Jan 2021. The survey was carried out from February to April 2021. Invitations were sent to therapists from 21 countries who met the inclusion criteria. One Hundred and twelve therapists were invited (68 directly, and 44 through “snowballing” nominations by other invitees). 63 agreed to participate and were sent a link to the survey. 54 took part in the first round and all 54 were invited to participate in all following rounds. 52 participated in the second, 47 in the third, and 43 in the fourth round. One participant completed only round 1, four participants completed only rounds 1 and 2, and six participants completed only rounds 1, 2, and 3. Three participants missed a single round then returned for subsequent rounds (one missed round 2, and two missed round 3). More participants were lost from countries outside of Europe and North America. The demographics of round four included a slightly higher percentage of certified hand therapists and an increase in average years of hand therapy experience indicating more experienced therapists contributed to round four than to round one. Participant demographics are presented in table 1, and geographic location and mode of invitation are presented in table 2, for rounds one and four.

Table 1

Participant Demographics

Demographics	**Round One n = 54**	**Round Four n = 43**
% OT, % PT	74%, 26%	79%, 21%
Average age	46 (range 28 – 65)	47 (range 28 – 65)
Average years practicing hand therapy	17 (range 1 – 35)	18 (range 3 – 35)
Certified (through a certifying organization)	43%	47%
Pursuing certification or previously certified	13%	12%
Highest level of education		
Other	4%	5%
Bachelor's	26%	28%
Masters	37%	30%
PhD clinical	9%	9%
PhD academic	24%	28%
Practice location		
Urban	72%	74%
Suburban	11%	12%
Rural	4%	2%
Mixed	13%	12%

Table 2

Participant Location and Mode of Invitation

Geographic Location	**Total Invited** (direct / snowball)	**Total Completed Round 1** (direct / snowball)	**Total Completed Round 4** (direct / snowball)
EUROPE			
Switzerland	**11** (4 / 7)	**6** (1 / 5)	**6** (1 / 5)
UK	**8** (4 / 4)	**6** (3 / 3)	**5** (3 / 2)
Ireland	**5** (2 / 3)	**1** (0 / 1)	**0** (0 / 0)
Netherlands	**4** (3 / 1)	**4** (3 / 1)	**4** (3 / 1)
Italy	**4** (1 / 3)	**1** (0 / 1)	**1** (0 / 1)
Denmark	**3** (1 / 2)	**2** (1 / 1)	**2** (1 / 1)
Spain	**1** (1 / 0)	**1** (1 / 0)	**1** (1 / 0)

Malta	**1** (1 / 0)	**1** (1 / 0)	**0** (0 / 0)
Total Europe	**37** (17 / 20)	**22** (10 / 12)	**19** (9 / 10)
NORTH AMERICA			
Canada	**19** (10 / 9)	**9** (5 / 4)	**6** (4 / 2)
USA	**19** (16 / 3)	**10** (9 / 1)	**8** (7 / 1)
Total N. America	**38** (26 / 12)	**19** (14 / 5)	**14** (11 / 3)
OTHER			
Australia	**9** (8 / 1)	**1** (1 / 0)	**0** (0 / 0)
South Africa	**7** (2 / 5)	**2** (1 / 1)	**2** (1 / 1)
Brazil	**6** (2 / 4)	**2** (2 / 0)	**1** (1 / 0)
Turkey	**4** (3 / 1)	**3** (2 / 1)	**3** (2 / 1)
India	**3** (3 / 0)	**1** (1 / 0)	**0** (0 / 0)
Qatar	**2** (1 / 1)	**1** (0 / 1)	**1** (0 / 1)
Iran	**1** (1 / 0)	**1** (1 / 0)	**1** (1 / 0)
Singapore	**1** (1 / 0)	**1** (1 / 0)	**1** (1 / 0)
Saudi Arabia	**1** (1 / 0)	**1** (1 / 0)	**1** (1 / 0)
Israel	**1** (1 / 0)	0	0
New Zealand	**2** (2 / 0)	0	0
Total Other	**37** (25 / 12)	**13** (10 / 3)	**10** (7 / 3)
GRAND TOTAL	**112** (68 / 44)	**54** (34 / 20)	**43** (27 / 16)

Round One

Eighty-seven percent (47/54) of participants provided a definition of **allodynia** consistent with the IASP definition. (Merskey & Bogduk, 1994), with minor variations in the wording. In addition to wording consistent with the IASP definition four other concepts included were: involvement of the nervous system, touch, other stimuli such as pressure / movement / vibration and, pain description. Seventy-eight percent (42/54) of participants provided a definition of **tactile hyperesthesia** consistent with the IASP definition (Merskey & Bogduk, 1994) with minor variations in the wording. Seventy six percent (41/54) of

participants used the term "tactile", "touch" or referenced the "skin" in their definitions which is consistent with “tactile” hyperesthesia.

No two participant’s definitions of **hypersensitivity** were the same. The term “stimulus” was used by 63% (34/54) and “touch” by 17% (9/54). Most participants did not comment on whether the stimulus should be considered noxious or innocuous. When addressing the response in their definition of hypersensitivity, the words participants used most frequently were "increased", "heightened" or "exaggerated". Many participants paired one of these words with a word to suggest what was increased. The two most common words were "sensitivity" and "response". Seventy two percent (39/54) of participants used words that did not suggest pain, and 15% (8/54) stated it was painful. Some noted it could be either painful or not.

A total of 730 assessment items were suggested. Pain intensity was the most frequently suggested assessment representing 24% of all items. This was followed by sensory assessments at 18%. Within the category of sensory assessments monofilaments were mentioned the most followed by non-nociceptive stimulation i.e., response to light touch / tapping / stroking / brush / pressure / materials / textures / dowels. Cortical representation assessments were mentioned the least representing 3% of the total.

A total of 918 treatment items were suggested. Sensory interventions were the most frequently suggested treatment representing 22% of all items with the term “desensitization” representing 39% of these sensory interventions. This was

followed by education (14%) and cortical representation (13%). Lists of all assessment and treatment categories and items in the sensory categories are presented in appendix B.

Twenty-nine suggested assessment items were dropped, and 28 suggested treatment items were dropped due to being suggested three or less times. Dropping infrequently suggested items was necessary to reduce participant burden in round two to promote participant retention. However, 10 assessment items were retained that did not meet these criteria (6 in the category of cortical representation, as there were many cortical representation treatments suggested but few assessments and we wanted to know if / how therapists were assessing for the suggested treatments, and 4 others for their relationship to, or possible overlap with other suggestions i.e., what alleviates pain, posture of body or limb, pain coping skills, and interview re work). Two treatment items were kept due to likely overlap with other categories (promoting bilateral hand activity and neurodynamic exercises).

Round Two

Possible addendums to the definition of **allodynia** received the following support 1) include ‘involvement of the nervous system’ 37% (19/52); 2) include ‘touch’ 27% (14/52); 3) other stimuli should be added such as pressure, movement, or vibration 23% (12/52) and 4) pain description be added 15% (8/52). As all were below the consensus threshold, they were dropped.

Participants were informed the IASP definition was supported as it is, and the allodynia subsection closed.

Fifty-two participants responded to questions regarding the IASP's definition of **hyperesthesia**. 90% (47/52) supported the current definition, 96% (50/52) agreed tactile hyperesthesia is "hyperesthesia due to a tactile stimulus" and 88% (46/52) agreed hyperesthesia could be either painful or not painful. Participants were informed the IASP definition was supported as it is, and the hyperesthesia subsection closed.

In defining **hypersensitivity**, 88% (46/52) voted to use the term 'stimulus'. However, there was less agreement around how the stimulus should be qualified with no dominant opinion evident regarding whether it should be considered innocuous, noxious, or "normal". Thirty-eight percent (20/52) of respondents felt it should not be qualified at all. To describe the response, participants voted for the following word preferences: "increased" 58% (30/50), 'heightened' 25% (13/50), and 'exaggerated' 13% (7/50). To describe what is increased: 52% (27/52) preferred the word "sensitivity" and 48% (25/52) preferred the word "response". Regarding whether hypersensitivity is a painful experience for the client, 69% (36/52) chose "it could be painful or not painful", 21% (11/52) "not painful but can be uncomfortable", while 8% (4/52) stipulated it was always painful, and 2% (1/52) specified it was not painful.

Participants indicated what their overall approach to pain is during assessment and treatment, see table 3 for a summary. When asked if their

approach to pain would be the same during all aspects of assessment and treatment, or be modified if circumstances warrant, the majority stated it would stay the same. However, 38% (20/52) indicated they would modify during assessment and 23% (12/52) would modify during treatment if circumstances warrant.

Table 3

Overall Approach to Pain During Assessment and Treatment

Overall approach to pain	Should stay the same or decrease	Can increase only slightly	Can increase moderately	Can increase and should not be a barrier
During assessment n = 52	12%	54%	23%	12%
During treatment n = 52	23%	54%	23%	0%

Twenty-five participants commented on how or why they would modify their assessment approach. Initial themes included (presented in order of most to least often suggested); may be justified to have more pain during assessment, consider psychosocial factors, consider timing within the session, and avoid pain. Eleven participants commented on how or why they would modify their treatment approach. Initial themes included consider; pain levels pre / post / and during, psychosocial factors, the origin of the pain, and neurological irritability.

Individual assessment and treatment items that reached consensus were added to summary tables (see tables 4 and 6 below). Items that were dropped in

each round, including the number of participants who provided an opinion and percent agreement, can be found in appendix C.

In response to the following question about pain intensity assessment*: "Participants provided many options for when they would use a VAS or NRS. Which of the following scenarios do you usually ask about to get a baseline for pain intensity?"* two scenarios met consensus (pain at rest 46/52 and pain at present 45/52), one met borderline consensus (pain with light use / daily activities 38/52) and five were dropped (two of the five that were dropped were related to evoked pain i.e., pain with touch in general 26/52 and pain with touch rated for specific materials 13/52). Preference for using an NRS was stronger with 28/52, preference for VAS was 12/52 while 12/52 indicated they used VAS and NRS about equally.

Fifty-two participants responded to the question "If you measure pressure pain threshold what is your preferred method?" 44% (23/52) reported not measuring this, 27% (14/52) use the rainbow pain scale (Packham et al., 2019; Spicher, Barquet, et al., 2020), 12% (6/52) use a 15g monofilament, 10% (5/52) use an algometer and 8% (4/52) chose "other method". Even with the monofilament approaches to pressure pain threshold testing combined there was less than 60% support for this type of assessment thus the item was dropped.

To assess for the detection of light touch 52 participants responded with 29% (15/52) indicating they don't use monofilaments to assess for light touch perception in the presence of allodynia, while 35% (18/52) would do this only

following peripheral nerve injury. In contrast, 37% (19/52) would assess light touch perception with monofilaments following a variety of injuries.

Placement of transcutaneous electrical nerve stimulation (TENS) was explored however, no recommendations met borderline or full consensus. Percentage support for each placement included “sympathetic ganglion / nerve trunk / neck shoulder area (assuming no allodynia in area)” 58% (11/19) “other” 53% (8/15), “not on allodynic area” 50% (15/30), and “contralateral” 28% (5/18).

Fifty-two participants responded to the question “Which statement best describes your approach to desensitizing for allodynia?” Low endorsements were given to the statements “I don’t use desensitization” 4% (2/52), and “touch directly on the painful area with no restrictions” 2% (1/52). More support was given for the descriptions “touch directly on the painful area, grade textures” 19% (10/52), “touch in an associated cutaneous nerve branch (somatosensory rehabilitation method)” 29% (15/52), and “touch next to / around but not on the painful area, grade textures, move towards allodynia” 46% (24/52).

To elicit what would contribute to participants decisions on when and how they would approach desensitization we asked the question “based on the results from round one it was apparent that many participants felt they would approach desensitizing differently under different circumstances. If any of the following conditions would influence how you approach desensitizing, please indicate what you would do differently.” Participants were then given five circumstances to provide comment on. Thirteen commented on “assumed peripheral vs. central

drivers of pain". The initial theme related to this was, if the pain is felt to be centrally driven cortical approaches are preferred. Twenty-four participants commented on "diagnosis of CRPS". Initial themes were, include centrally focused interventions for CRPS, and avoid pain increase. Fourteen comments were provided for "confirmed nerve injury", eighteen for "time since injury" and fifteen for "nociplastic vs. neuropathic pain". Unfortunately, the wording in these last three was not clear enough and many answers could not be categorized as to which condition the comment was referring to. Of the comments where it was clear what the response referred to no themes were noted.

Fifty-one participants responded to the question "Which of the following statements best describes your opinion regarding whether an area of allodynia should, or should not, be covered (with a splint, gel, wrap, glove etc.) to reduce contact and provide protection from being touched?". There was low support for "An area of allodynia can be covered but this should be weaned quickly on a pre-set schedule regardless of pain symptoms" 12% (6/52). Thirty-three percent (17/52) indicated that it should not be covered, and 55% (28/52) agreed with "An area of allodynia can be covered, and this should be weaned according to the client's pain level". Fifteen participants commented on the use of a cover. Initial themes were a) choose specific tasks / times to use, b) it should be comfortable, c) use if it helps improve function, d) use if needed for other purposes, e) it depends on the client, and f) should not use a cover. Most comments suggested a preference to not cover but indicated that sometimes it may be needed.

Round Three

Consensus was not reached on whether the stimulus in **hypersensitivity** is considered innocuous 47% agreed (22/47) or if it could be either noxious or innocuous 51% agreed (24/47); a single respondent specified the stimulus for hypersensitivity should be considered noxious. Using both the words “increased / heightened” in the definition was supported by 91% (43/47). Six comments were made, five of which expressed opposition to the use of the two words. Forty-four percent (20/45) preferred the word “sensitivity” and 56% (25/45) preferred “response”. Eighty-seven percent (41/47) agreed ‘hypersensitivity could be painful or not painful’.

Several functional questionnaires had been recommended. As we desired our results to be internationally applicable and English was not the language many participants used in their practice, we suggested grouping functional assessment recommendations into the two categories of: an assessment of client-identified important activities, and an assessment of upper extremity function including standardized items. This grouping was supported by 89% (41/46). The additional recommendation of utilizing one assessment from each group was supported by 85% (40/47).

We asked if some assessments and treatments that had already been accepted, or were borderline in reaching consensus, should be applied within or outside the area of allodynia if this was not inherently clear. This re-visitation resulted in one assessment (the Ten Test) which had just reached consensus

after round two 76% (13/17) not reaching consensus after round three. There was low support for use of the Ten Test both within the area of allodynia 39% (18/46), and outside the area 31% (14/45).

We considered dropping the use of monofilaments to assess for detection of light touch due to a lack of consensus in round two for any of the options. However, on review we identified the wording did not distinguish whether this testing was on the allodynic area directly or on adjacent areas in the hand. When asked about this in round three 29% (13/45) indicated it would be helpful on the area of allodynia and 57% (27/47) indicated it would be helpful adjacent to the area of allodynia. As neither met borderline consensus this area of inquiry was closed.

No specific approach to TENS reached borderline consensus in round two. However, to determine if there was support for the modality in general, we asked if participants “recommend TENS as a treatment modality that may help reduce allodynia and its impact”; 79% (23/29) agreed.

We further explored the reasoning behind whether an area of allodynia should be covered or not. Seventy-nine percent of participants (37/47) supported the statement “I recommend not covering an area of allodynia in general. However, there are certain circumstances when covering may be appropriate”. Based on the comments from round two, statements related to circumstances where covering may be considered were drafted and voted upon. Participants were asked, if they prefer not to cover an area of allodynia, to indicate why. Three

options were given. Forty-one percent (12/29) selected “to desensitize the area”, 48% (14/29) chose “a cover will contact the area and may contribute to the pain” and 10% (3/29) chose “for a different reason”. Six comments were provided expressing potential for undesired altered cortical processing, covering may increase fear or feeling the need to protect, and a cover may increase pain through contact.

In previous rounds participants had indicated that they would approach desensitization differently depending on underlying mechanisms including whether the allodynia was felt to be more due to peripheral or cortical changes. Thus, we asked “*If the allodynia is felt to be more due to peripheral drivers direct desensitization on the area is appropriate”* 61% (28/46) agreed. We also asked: *“If the allodynia is felt to be more due to central drivers, direct desensitization on the area is not appropriate and treatments that focus on altering cortical representation of the limb are more appropriate”,* 78% (35/45) agreed.

Looking again at terminology around what participants call specific tactile stimulation approaches we posed questions which gave an approach and a term to describe it and asked if participants agreed. Terms were chosen based on the literature and previous responses within the survey. None of the suggested terms met consensus. The statements and associated level of support were: *“I agree that touching directly on an area of allodynia is appropriately described by the term ‘desensitization’*”, 55% (26/47) agreed, and *“I agree that touching in a distant anatomically associated cutaneous nerve branch is appropriately*

described by the term 'counterstimulation'", 65% (30/46) agreed. It is not clear in the literature or in previous rounds which term is best used to describe touching next to / around but not directly on an area of allodynia. Thus, we asked the participants if they agreed that the term "desensitization" best describes touching next to / around but not directly on an area of allodynia, 47% (22/47) agreed, or if the term "sensory relearning" best describes this, 42% (19/45) agreed.

Round Four

The remaining issue in defining **hypersensitivity** was whether participants agreed the stimulus may also be noxious. Sixty-five percent (28/43) agreed: thus, as consensus was not reached, "noxious" was not included in the definition. Eighty-four percent (36/43) supported the following proposed hand therapy definition of hypersensitivity; **"increased / heightened sensitivity and response to innocuous stimuli which may be experienced by the client as either painful or not painful"**. Ten participants commented on the definition with thirteen suggestions for changing of wording. Comments were categorized as: prefers "and / or" or just "or" between sensitivity and response, additional endorsement for "sensitivity" or "innocuous", or, noting they did not support the term "response", or the term "client".

Items that were dropped after round two, three and four are summarized in appendix C. Items that met consensus are summarized in the tables below. Recommended assessments to consider and assessment approach recommendations are presented in tables 4 and 5. Recommended treatments to

consider and treatment approach recommendations are presented in tables 6 and 7. The introduction statements to each of the tables all met consensus.

Table 4

Recommended Assessments to Consider

Allodynia of the hand Assessment recommendations	**Number of therapists providing an opinion, % agreement**
Therapists should determine which assessment components may be most helpful based on the unique concerns of each client. The following assessments are recommended for you to consider. Not all will be appropriate for every client.	n = 42, 98%
Interview questions re: pain, and factors which may influence pain	
What triggers the pain to increase	n = 52, 98%
What alleviates the pain	n = 52, 96%
Medication use	n = 52, 90%
Is there difficulty with exposure to cold	n = 52, 81%
Client's perception re cause of pain	n = 52, 94%
Mood / anxiety / depression	n = 52, 94%
Current approach to coping with pain	n = 52, 94%
Social / family support	n = 52, 92%
Sleep habits	n = 52, 87%
Past approach to pain / stress	n = 52, 81%
Interview questions re function	
Discuss use of hand in activities of daily living	n = 51, 100%
Discuss use of hand at work	n = 51, 96%
Discuss daily activity schedule	n = 50, 88%
Questionnaires	
Douleur Neuropathique 4	n = 12, 83%
McGill Pain Questionnaire	n = 39, 79%
when using self-report questionnaires to assess function use both an assessment of upper extremity function with standardized items (such as the Patient-Rated Wrist/Hand Evaluation - PRWHE), and an assessment of client-identified important items (such as the Patient-Specific Functional Scale - PSFS)	n = 47, 85% to include both types of assessment n = 32, 81% for PRWHE n = 22, 91% for PSFS
Pain Catastrophizing Scale	n = 39, 77%
Observation	

General observation of use of hand	n = 51, 96%
Observation of the hand during specific tasks	n = 48, 98%
Posture of the body and limb	n = 51, 78%
Assessment of pain intensity	
Use NRS or VAS to assess pain at present	n = 45, 87%
Use NRS or VAS to assess pain at rest / not moving or using hand	n = 46, 88%
Use NRS or VAS to assess pain with light use / daily activities	n = 46, 98%
Assessment of pain location	
Clinician drawn using Somatosensory Rehabilitation Method protocol (“allodynography”)	n = 19, 89%
Client drawn on a hand or body diagram	n = 39, 85%
Described in words in chart notes based on the client’s description	n = 47, 77%
Assessment for a central component	
Laterality – using app or computer	n = 35, 86%
Laterality – using pictures	n = 47, 81%
Mirror therapy – which movements increase pain	n = 24, 82%
Mirror therapy – assess for asynchiria / dysynchiria	n = 35, 80%
Client to draw the hand as it feels	n = 17, 76%
Ability to imagine movement	n = 35, 80%
Sensory / physical assessment	
Response to light touch on the area of allodynia	n = 47, 77%
Active ROM of affected and unaffected joints	n = 48, 92%
Use of the Budapest criteria	n = 40, 88%
Soft tissue quality	n = 47, 85%
The Ten Test (see text for details regarding low agreement on location of use)	n = 17, 76%

Key: VAS = visual analogue scale, NRS = numeric rating scale, ROM = range of motion

Table 5

Assessment Approach Recommendations

Allodynia of the hand Assessment approach recommendations	**Number of therapists who provided an opinion, % agreement**
Therapists should determine throughout the assessment whether it is appropriate (or necessary) for pain to increase during the assessment process. Considerations include:	n = 40, 93%
Consider conducting assessments that may increase pain if they will provide important data for your treatment plan (i.e., provoking pain for diagnostic purposes)	n = 47, 77%
Consider conducting assessments that may increase pain by dispersing the assessments over the session to avoid summation	n = 42, 76%
Consider being more cautious to avoid pain increase if the client is anxious / fearful or appears to have poor pain coping strategies	n = 47, 98%
Consider being more cautious to avoid pain increase if the assessment appears to have provoked a physiological response (e.g., sweating, temperature change)	n = 47, 89%

Table 6

Recommended Treatments to Consider

Allodynia of the hand Treatment recommendations	**Number of therapists who provided an opinion, % agreement**
Therapists should determine which treatment components may be most helpful based on the unique concerns of each client. The following treatments are recommended for you to consider. Not all will be appropriate for every client.	n = 43, 95%
Sensory intervention	
If the allodynia is felt to be more due to central drivers, direct desensitization on the area is not appropriate and treatments that focus on altering cortical representation of the limb are more appropriate	n = 45, 78%
Sensory reeducation (stereognosis, localization, discrimination) outside the area of allodynia	n = 44, 75%

Tactile stimulation (various approaches – see text)	n = 50
Other physical intervention	
Approaches to improving movement (with allodynia in the presence of reduced movement**)**	
Bilateral hand activities	n = 50, 90%
Light grasping, pinching	n = 51, 80%
Active range of motion of joints outside the area of allodynia	n = 45, 84%
Active range of motion of joints within the area of allodynia	n = 46, 76%
Nerve gliding (in the presence of neural tension)	n = 46, 80%
Active use of the hand in fine motor tasks	n = 42, 83%
Edema management (with allodynia in the presence of edema**)**	
Positioning / elevation	n = 49, 88%
Encouraging movement to promote circulation	n = 47, 73%
Light aerobic exercise	n = 46, 78%
Compression *	n = 46, 78%
Manual edema techniques *	n = 39, 77%
Modalities	
Transcutaneous electrical nerve stimulation (TENS)	n = 29, 79%
Manual techniques	
soft tissue work / mobilization / scar massage *	n = 42, 76%
'Top down' interventions	
Functional intervention	
Modify activities / use of devices	n = 52, 92%
Promote use of hand in meaningful tasks	n = 52, 92%
Promote use of hand in activities of daily living	n = 52, 88%
Graded exposure to activity	n = 51, 86%
Gloves for temperature control *	n = 48, 85%
Gloves to reduce vibration *	n = 36, 78%
Splinting for neurological deficit *	n = 47, 87%
Splinting to promote functional use *	n = 45, 78%
Techniques to alter cortical representation	
Promote bilateral activities	n = 45, 91%
Imagined movements	n = 42, 81%
Imagined sensations	n = 35, 77%
Graded motor imagery	n = 33, 76%
Laterality training via an app	n = 31, 77%
Laterality training via pictures	n = 46, 80%
Mirror therapy – motor focus	n = 46, 85%
Mirror therapy – sensory focus	n = 38, 82%
Education	
Managing consequences of nerve injury	n = 52, 98%
Assessment results and treatment plan	n = 52, 98%
Activity / exercise schedule	n = 51, 90%
Sleep hygiene	n = 52, 90%
Pain education	n = 52, 88%
Medical aspects of the condition	n = 52, 83%

Importance of supports	
Providing a home program	n = 52, 100%
Involving counselling re coping as needed	n = 52, 98%
Involving physician re medication for pain control as needed	n = 52, 98%
Techniques delivered in the hand therapy setting	
Goal setting	n = 51, 98%
Reassurance / covey security	n = 44, 95%
Cognitive or dialectical behaviour therapy	n = 31, 90%
Breathing exercises for relaxation	n = 46, 83%
Mindfulness meditation	n = 42, 79%

*see text below for discussion re touching or not during treatment

Manual edema techniques reached consensus in round 2 and are included. However, when we asked in round three if it should be performed in a way that avoids touching the area it became borderline in reaching consensus 74% (34/46). In round four we asked if the allodynic area should be touched during manual edema techniques 2% agreed (1/43), 40% (17/43) indicated it should not be touched, and 58% (25/43) chose the response “It depends on the client, sometimes touching the area of allodynia is appropriate, sometimes it should be avoided during manual edema techniques”. The same questioning was used to explore if touching the area of allodynia should be included during soft tissue work / mobilization / scar massage; 12% (5/41) agreed, 37% (15/41) recommended to avoid, and 51% (21/41) chose the “it depends” option as described above. As the statement “*If the allodynia is felt to be more due to peripheral drivers direct desensitization on the area is appropriate*” was borderline in reaching consensus in round three it was asked again in round four with slightly altered wording to increase clarity i.e., *“If the allodynia is felt to be*

more due to peripheral drivers, i.e. peripheral sensitization, touching directly on the area of allodynia may be helpful". This received slightly more support at 66% (27/41) but did not reach consensus.

Table 7

Treatment Approach Recommendations

Allodynia of the hand Treatment approach recommendations	**Number of therapists who provided an opinion, % agreement**
Therapists should determine throughout the treatment whether it is appropriate (or necessary) for pain to increase during treatment, or in response to treatment. Considerations include:	n = 42, 95%
Consider being more cautious to avoid pain increase if the client is anxious / fearful or appears to have poor pain coping strategies	n = 46, 96%
Consider being more cautious to avoid pain increase if the client is "irritable in a neurological sense"	n = 46, 91%
Consider adjusting treatment based on the source of the pain, i.e. is pain increasing due to allodynia or another source of nociception?	n = 47, 91%
Consider adjusting treatment based on allodynia levels before, during and in between sessions	n = 47, 94%
Consider being more cautious to avoid pain increase if allodynia is part of the diagnosis of complex regional pain syndrome (CRPS)	n = 46, 87%
Consider more central treatments if allodynia is part of the diagnosis of CRPS	n = 46, 91%

Table 8 presents a summary of information related to whether an area of allodynia should be covered or not (some met consensus while others did not).

Table 8

To Cover an Area of Allodynia or Not

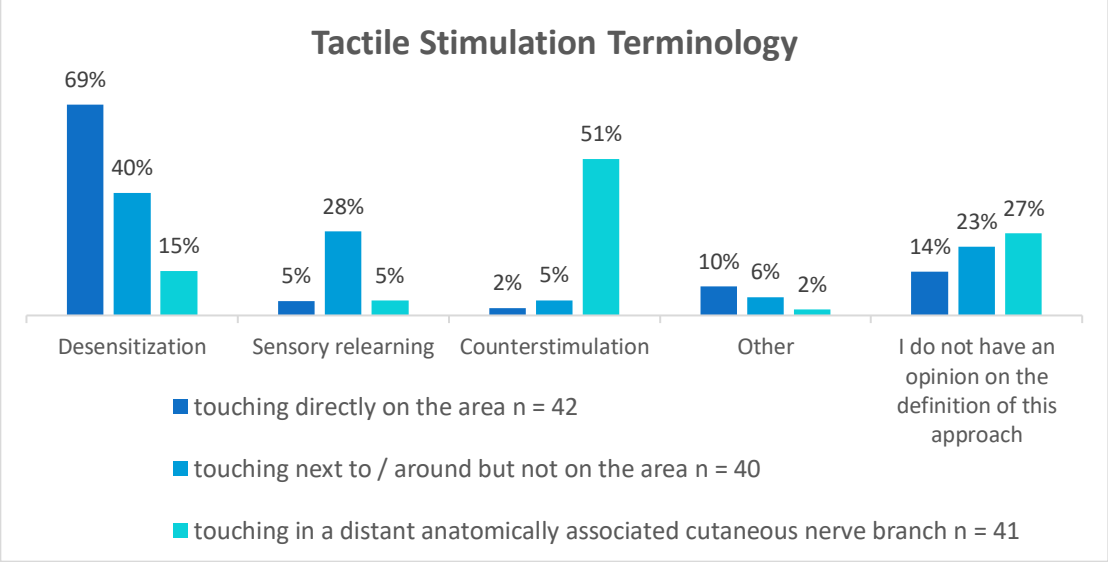
It was agreed that an area of allodynia is best left uncovered. (n = 47, 79%) **However, the reasons to not cover were diverse.** (none met consensus)	**Number of therapists who provided an opinion, % agreement**
It is better to leave the area of allodynia exposed as a cover will contact the area and may contribute to the pain	n = 29, 48% round 3
It is better to leave the area of allodynia exposed to desensitize the area	n = 29, 41% round 3
It is better to leave an area of allodynia exposed as covering it may contribute to undesirable altered cortical processing	n = 43, 74% round 4
It was agreed that in some circumstances a cover may be appropriate. Reasons a cover may be considered. (all met consensus)	
If a cover is necessary, it should be applied in a way that does not cause pain to increase (as much as is possible)	n = 46, 93%
Consider using a cover for other medical concerns such as edema management or contracture treatment	n = 42, 81%
Consider using a cover for specific tasks only as needed	n = 46, 80%
Consider using a cover if it helps the client use their hand more functionally. Wean the cover gradually	n = 42, 76%

Terminology around specific tactile stimulation approaches was explored again. No approach had a term used to describe it that reached consensus. The term “flooding” was provided as an option for voting on but was selected only once for two of the tactile stimulation approaches (interestingly not in the “touching on” approach) thus the two responses for “flooding” were included within the “other” category. The percentage support was based on all options given including the option of “I don’t have an opinion on the definition of this approach” as it was deemed relevant to capture this information. There was a

preference for “desensitization” to describe touching directly on an area of allodynia by 69% (29/42). Nine out of the ten comments in response to this terminology question expressed opposition to the approach of directly touching on an area of allodynia as a treatment technique. The term “counterstimulation” was preferred for touching in a distant anatomically associated cutaneous nerve branch 51% (21/41). Touching next to / around but not on the area was described as “desensitization” by 40% (16/40) and as “sensory relearning” by 28% (11/40). If those with no opinion were excluded from the analysis these numbers would be changed as follows; desensitization 81% (29/36), counterstimulation 70% (21/30) touching next to / around but not on, as desensitization 52% (16/31) and as sensory relearning 36% (11/31). Figure 1 summarizes the terms used to describe each of the three tactile stimulation approaches.

Figure 1

Terms Used to Describe Tactile Stimulation Approaches



Chi square analysis was performed to examine the association between geographic location, or years of experience, and whether participants recommended touching an area of allodynia when peripheral sensitization was suspected. No statistically significant association was found (p value set at .05) for geographic location X^2 (2, n = 41) = 4.47, p = .11 or for years of experience X^2 (2, n = 41) = 0.73, p = .69. Although not statically significant, more participants agreed with touching an area of allodynia when peripheral sensitization is suspected in North America and other countries, whereas there was an equal split by participants from Europe as shown in figure 2 below. Touching on the area when peripheral sensitization is suspected was also slightly more endorsed by more experienced therapists as shown in figure 3.

Figure 2

Participant Support for Touching an Area of Allodynia When Peripheral Sensitization is Suspected by Geographic Location.

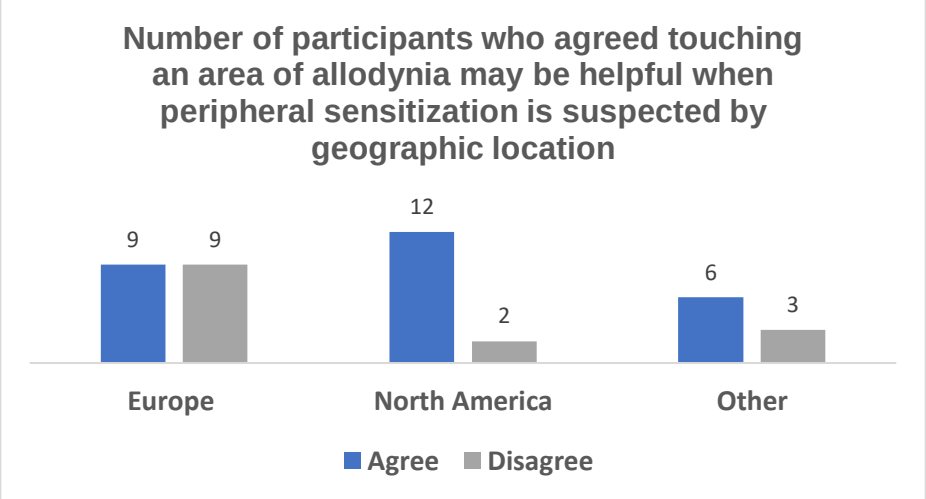
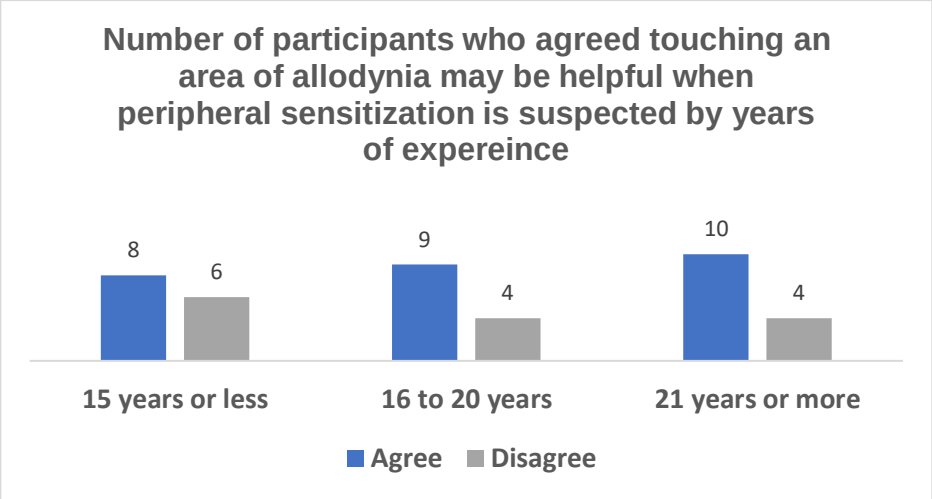


Figure 3

Participant Support for Touching an Area of Allodynia When Peripheral Sensitization is Suspected by Years of Experience.



Chi square analysis was also performed to examine the association between geographic location, or years of experience, and terminology to describe touching near but not on an area of allodynia. Results were not statistically significant for an association for the terms “desensitization”, “sensory relearning”, or “other” to mean touching near an area of allodynia and geographic location X^2 (4, n = 31) = 5.65, p = .23 or for years of experience X^2 (4, n = 31) = 1.08, p = .9. For these calculations the data for those who responded, “no opinion” were removed and the “other” category was recoded to include “counterstimulation”, “flooding”, and “other” due to low support for these terms individually. Figure 4 below presents preference for terminology by geographic location and figure 5 by years of experience. More participants from Europe and other countries

supported the term desensitization to describe touching near an area of allodynia, while there was an equal split in North America. Regardless of experience, the term desensitization was preferred over sensory relearning for touching near an area of allodynia. However, given the small numbers and lack of statistical significance these results may not be representative of the broader opinions of hand therapists.

Figure 4

Participant Support for Terminology to Describe Touching Near an Area of Allodynia by Geographic Location.

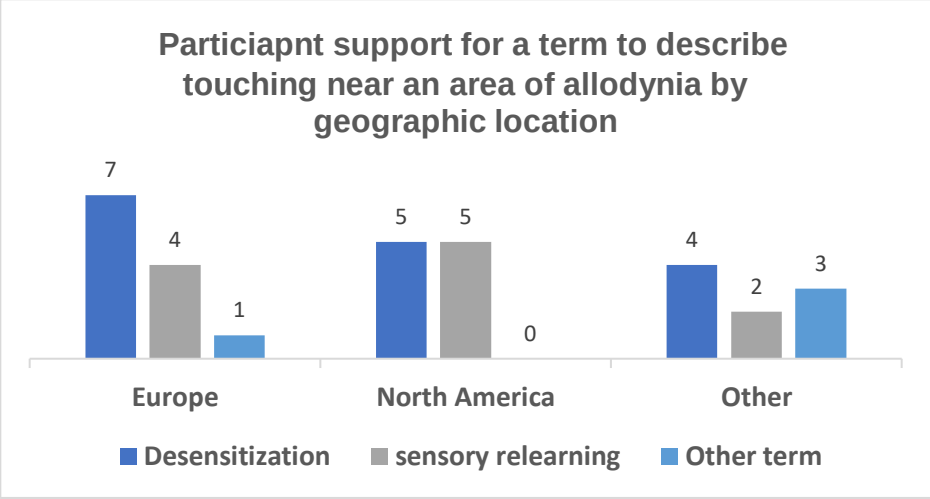
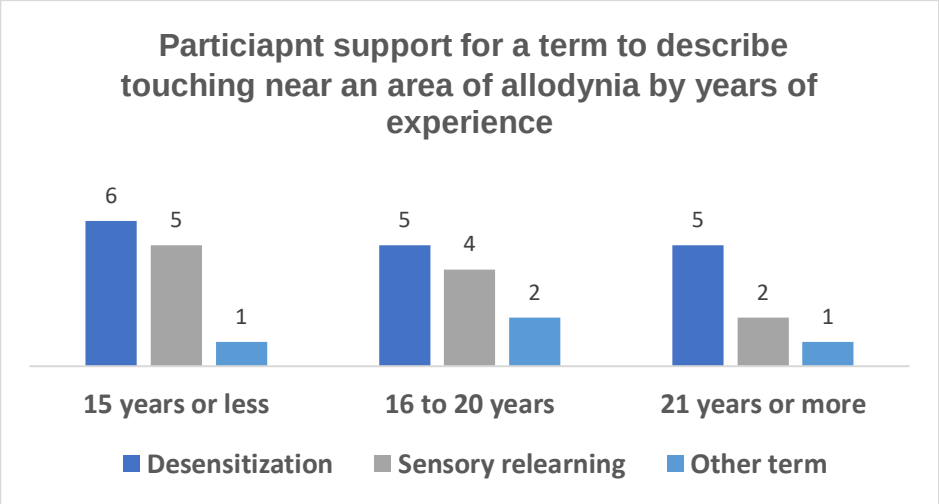


Figure 5

Participant Support for Terminology to Describe Touching Near an Area of Allodynia by Years of Experience.



Themes

Two themes related to assessment and treatment of allodynia were observed across the rounds. The themes were 1) **assessment and treatment decisions depend on the client** and 2) **to touch or not to touch.** For theme one, deeper exploration over the rounds sought to determine what factors were considered most important in clinical decision making i.e., what do decisions depend on? Three sub themes were observed i.e., **assessment and treatment decisions depend on a) the mechanisms contributing to the allodynia, b) psychosocial factors and c) functional status.** These subthemes were influential and informed many of the individual assessment and treatment items

recommended in tables 4 and 6, as well as the approach recommendations found in tables 5 and 7.

Theme two, to touch or not to touch, represented an area of more variability and uncertainty. Although the participants' answers regarding approach to pain show a preference that pain should not increase, consensus was not reached in many of the areas explored. Table 9 below is a joint display summarizing the qualitative and quantitative data that were influential in developing these final themes. Quantitative support for the themes is detailed in tables 4 to 7 above. Qualitative support for the themes is presented with related quotes from participants following table 9.

Table 9

Qualitative and Quantitative Data That Were Influential in Developing Final Themes

	Evidence for themes by round **Qualitative / Quantitative (all met consensus unless numbers are provided to indicate level of support)**			
Theme	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Theme 1 **Assessment and treatment decisions depend on the client**	18 general comments that assessment and treatment decisions depend on the client	17 comments that it depends on the client 7 comments that the decision to cover an area of allodynia or not depends on the client	4 comments that "it depends" on the client	Introductory statements to assessment and treatment recommendations include considering the unique concerns of each client Approximately 50% chose "it depends" in response to whether an

				allodynic area should be touched or not during specific treatments (see below)
Theme 1 Subtheme a) Assessment and treatment decisions depend on **the mechanisms contributing to allodynia**	30 comments related to assessment, and 35 related to treatment, indicating approach would be different based on underlying mechanisms (type of injury central vs. peripheral drivers of pain, cause of pain)	7 suggest cortical approaches for centrally driven pain 2 suggest touching on the area for peripherally driven pain 14 suggest cortical approaches when allodynia is associated with a diagnosis of CRPS Consider techniques to alter cortical representation	Consider: -avoiding pain increase if the client is "irritable in a neurological sense" -adjusting treatment based on the source of the pain -use of central treatments if the allodynia is part of the diagnosis of CRPS -being more careful to avoid pain increase with CRPS	66% 27/41 agreed If the allodynia is felt to be more due to peripheral drivers, i.e. peripheral sensitization, touching directly on the area of allodynia may be helpful
Theme 1 Subtheme b) Assessment and treatment decisions depend on **psychosocial factors**	11 comments that assessment and treatment decisions depend on psychosocial factors (such as fear, anxiety, and ability to cope) 30 Suggested psychosocial assessments and 65 suggested psychosocial / support interventions	Consider: -interview topics re coping and support -involving other health care providers in the care of a client who is struggling emotionally -education -psychosocial interventions	Consider being more cautious to avoid pain increase if the client is anxious / fearful or appears to have poor pain coping strategies 2 comments that increasing fear or feeling the need to protect are reasons to not cover an area of allodynia	Consider use of the Pain Catastrophizing Scale
Theme 1 Subtheme c) Assessment and treatment decisions depend on	10 comments that assessment and treatment decisions depend on functional status	Consider: -discuss use of hand in ADLs and work, and activity schedule	when using self-report questionnaires to assess function use both an	

functional status	29 functional assessments and 74 questionnaires that assess or include a functional component 65 functional interventions	-Use of functional questionnaires -Use NRS or VAS to assess pain with light use / daily activities -Observe hand during functional use -Functional interventions (promoting hand use, use of devices etc.) 8 suggest an area can be covered if it improves function or for specific tasks.	assessment of upper extremity function with standardized items, and an assessment of client-identified important items	
<u>Theme 2</u> **To touch or not to touch**	"desensitization" suggested 79 times (2 stated directly on, 11 stated near, 66 did not specify location) Fluidotherapy / sensory bombardment / immersion suggested 30 times SRM techniques suggested 49 times	Approach to "desensitization" Touch near but not on 24/50 SRM 15/50 Touch on and grade textures 10/50 Touch on with no restrictions 1/50 Educate to "Avoid stimuli that increase pain" not agreed upon: 29/52 important 13/52 neutral 10/52 not important Interventions that use direct touching had a mixed response (immersion / bombardment and fluidotherapy / whirlpool) each had approx. 1/3	61% (28/46) agreed that with peripheral drivers direct desensitization on the area is appropriate 39% (18/46) agreed graded pressure through putty / tapping / massage may be helpful on the allodynic area 49% (23/47) agreed sensory reeducation may be helpful on the allodynic area	Should an area of allodynia be touched during manual edema techniques: 1/43 yes 17/43 no 25/43 it depends Should an area of allodynia be touched during soft tissue work / mobilization / scar massage: 5/41 yes 15/41 no 21/41 it depends 9 comments that touching on an area of allodynia is not an appropriate treatment

		indicating they are helpful, neutral, or are not helpful 31 suggestions for avoiding, or ways to minimize pain 4 suggestions to touch directly on 12 indicated it may be necessary for pain to increase during assessment		

Key: CRPS = complex regional pain syndrome, SRM = Somatosensory Rehabilitation of Pain Method, ADLs = activities of daily living, TENS = transcutaneous electrical nerve stimulation, NRS = numeric rating scale, VAS = visual analogue scale.

Theme 1: Assessment and Treatment Decisions Depend on the Client.

Participants were clear that assessment and treatment is unique to each individual. "*The assessment varies according to the presentation of the patient and type of pain experienced as well as the functional and psychosocial aspects affected.*" Physical, psychological, and social factors were also expressed as influencing decisions. "*Every person is individual, and their healing process is influenced by their physical, psychological and social stress factors or resources. It is therefore important to include these components in the recording and treatment and to evaluate them again and again.*" The need to tailor assessment choices based on a wide variety of specific factors was also reported: "*Depending on the cause (diagnoses) and the location and depending on the presence of*

impairments (hypersensitivity, allodynia, loss of mobility (AROM), diminished grip strength, etc.) and activity limitations and participation restrictions, assessment instruments could be more or less helpful and recommended." In contrast, several participants stated they could not comment, as the factors are too many and varied*; "I agree to all of the recommendations, but this is based on 'it depends'. That is, I think they are excellent recommendations for the right patient. I would not use all of the recommendations all of the time … 'it depends'…"* and *"Difficult to respond to this concretely as patients are so variable.".* The consideration of timing of assessments and treatments was also noted as influencing decisions, "*I always adjust my treatments based on patient mood and response, so some of these treatments just depend on whether it is right for that specific patient at that specific moment*.".

Theme 1: Subtheme a) Assessment and Treatment Decisions Depend on the Mechanisms Contributing to the Allodynia. Many participants expressed they would approach allodynia differently based on what they felt was causing the pain; *"In my opinion it is important to identify the cause / type of pain and to approach it differently".* It was also recommended the assessment be adjusted based on whether the pain is persistent or evoked; *"The presence of persistent pain vs. evoked would be for me a reason to change the assessment".*

The mechanisms driving the allodynia were considered to be either peripheral or central and recommendations differed based on this distinction; *"Some interventions are to help normalize the brain, others are to impact nerve*

signals at the source of injury, and some address just reincorporating an injured body part into normal use – this pain may be due to neglect." and *"If I assume the driver of pain is peripheral (e.g., small allodynic zone) I would use either desensitization directly on the allodynia or, if this technique is painful I would use the SRM. If I suspect it is from central drivers: I use SRM.".* The proposed recommendation related to peripheral sensitization did not meet consensus (n = 41, 66%) i.e., "If the allodynia is felt to be more due to peripheral drivers, i.e., peripheral sensitization, touching directly on the area of allodynia may be helpful". Some participants supported peripherally based treatments for peripheral sensitization; *"For peripheral drivers, I would do desensitization techniques." and "With changes in the sensibility of the nociceptors you have to treat the nociceptors e.g., by desensitization.".*

Participants commented on the need for cortically based treatments for centrally driven pain; *"With cortical changes, you need to influence the brain to change the interpretation of the peripheral nerve stimuli e.g., by Graded Motor Imagery."* and *"For central drivers, I would do techniques such as graded motor imagery, aerobic exercise, diaphragmatic breathing.".* Differentiating between allodynia, and allodynia associated with CRPS was expressed: *"We must consider different conditions. To treat CRPS is NOT to treat its allodynia. They are two different conditions."*. Not all participants agreed that cortically based treatments will impact allodynia stating that graded motor imagery may help reduce sensations of stiffness / temperature, but not allodynia, as the nerve fibres

involved are different; *"GMIP is decreasing sensations of joint stiffness (AB neuro fibre lesions) and boiling / warm / cold / freezing sensations.".* Another participant agreed that GMI can be used for pain associated with movement but that it would not be used instead of the SRM approach; *"when there is a connection between moving and pain I will sometimes use GMI in addition to SRM but never as a substitute.".* Graded motor imagery was recommended when there are definite cortical changes; *"Graded motor imagery is used mostly when there are definite cortical changes that have occurred, this is often evident in the presentation and use of the upper limb.".* Cortically based treatment for allodynia with a mirror was described*; "I noticed during my practice that patients would benefit from the GMIP/Mirror therapy only if they are experiencing pain / dysesthesia while moving or stimulating the unaffected side (dysynchiria). In a similar way we tend to use mirror therapy post amputation only if they have phantom limb pain. I am currently using the mirror as a tool to decrease allodynia (size and intensity) by performing a "graded desensitization program" on the unaffected side.".*

Theme 1: Subtheme b) Assessment and Treatment Decisions Depend on Psychosocial Status. Participants stated they would approach assessment and treatment differently depending on psychosocial factors; *"I think it depends on the psychosocial state. If there is a lot of anxiety or fear, I may try to minimize any pain.".* Being aware of emotional pain during assessment and conscious of the therapeutic alliance was recommended; *"It also depends on if patients present a high score on the McGill pain questionnaire in the emotional type of*

pain. If pain increases too much in the assessment for this type of patient, you will most likely lose the therapeutic alliance.". Anxiety was felt to be a factor influencing the provision of pain education and support; *"The early detection and treatment of possible sensory disorders as well as the pain education and adequate guidance / accompaniment of the client (especially the unwilling, anxious clients) can prevent the pain from becoming chronic".* When deciding whether an area of allodynia should be covered or not, emotional factors such as fear or confidence, were taken into considerations: *"Personalize the treatment – covering may give some more confidence, and others may use the limb less."* and regarding using a covering; *"it can potentially increase neglect and fear.".*

Theme 1: Subtheme c) Assessment and Treatment Decisions Depend on Functional Status. Assessment of function through observation and standardized testing was suggested often; *"Observation of how he uses his hand in activities and which activities does he find (most) important to be able to perform (maybe by the use of the Canadian Occupational Performance Measure)".* The degree to which the pain interfered with function would influence assessment; *"the pain while bothersome does not impact his daily activities, so I decided to do a more abridged version of the assessment".* The importance of encouraging functional use was evident in many comments; *"review of ADLs / IADLs and education of adaptive ways to complete them while respecting the treatment of the hyper sensation"* and *"engagement in functional everyday tasks /ADL's",* and *"Encourage use of the hand and arm in normal function.".* Functional

impact was given as a reason for differences in approach to treatment between the vignettes. When asked why treatment was different between the cases answers included *"Differences in functional impact", "Case Study 2 appeared to have a higher tolerance of integrating his hand in ADLs and therefore use of counter stimulation seemed counter-intuitive"* and *"I think the pain/sensitivity has resulted in more disability and significant impact on their daily living,".*

Function was considered when deciding whether or not to cover an area of allodynia. In general covering was not recommended but if it would help increase functional use, then it was considered; *"I try to avoid using splints/covers, but sometimes this helps integrate the hand into functional activities and things the patient enjoys doing enabling participation... so I'm not going to say should not be covered."* and *"I may use a splint or glove or gel to allow participation in particular functional activities but not for constant use."* and *"Ideally I wouldn't cover an area of allodynia but for some patients it helps to get them going.".*

Theme 2: To Touch or Not to Touch.

Participants agreed that increased pain during assessment is acceptable if necessary to inform the treatment plan; *"Assessing is necessary for diagnosing the problem. If you don't diagnose properly, you will never be able to choose the right treatment, whether it is pain from an allodynia or pain from a tendonitis. During every assessment of a complaint 'pain' it is necessary to assess what stimulus (touching, moving, or anything else) is provoking the pain. The assessment is clear enough when you just find the painful spot or stimulus and*

immediately afterwards leave it alone.". The majority of participants endorsed a pain contingent approach to assessment, where pain should not be substantially increased by the assessment process; a pain contingent approach to treatment was even more strongly supported. Some participants felt it was helpful to expose the area of allodynia to touch during treatment and during daily activities; *"Usually I ask patients to uncover the area, (if tolerated), and expose it to the air, or place in cool or warm water (their preference) grasping objects or washing a dish (functional). At a minimum the area is usually uncovered during OT treatment sessions.".* Some stated they would touch directly on the area of allodynia but only if due to peripheral sensitization; *"Will gently touch over specific area of pain.* [for peripheral drivers]*"* or would touch only if pain was nociplastic; *"I have them desensitize right on the area of concern for nociplastic pain, but again avoid desensitizing right on areas driven by neuropathic pain mechanisms.".* Being cautious to not increase pain was expressed: *"I'm very careful using tactile desensitization in CRPS patients. I believe not all patients will benefit from it, in fact, some tend to experience more pain during this technique.".* Touching the painful area and surrounding areas was also suggested; *"there are times when both the areas affected, and the ones around should be targeted".* The discrepancy between whether to touch or not was evident in an answer which both suggests touching the painful area and educating about the importance of not being exposed to painful stimuli; *"- Desensitization (Direct application of a tolerable stimulus such as texture, particles, and vibration to the painful area to*

improve the pain threshold), - Patient Education (The person should be informed about the importance of not being exposed to a painful stimulus)".

In contrast many participants held the view that an area of allodynia should not be touched at all; *"In the case of allodynia, the rule is; don't touch."* and *"I would never test the sensibility and / or the AROM / PROM nor the use of the affected joint(s) if there is a mechanical allodynia present".* When responding to questioning about what term best described touching an area of allodynia many participants expressed that it is not an appropriate treatment, commenting that it is; *"counter therapeutic", "pain provocation", "inappropriate"* and," *In my opinion an allodynia should not be touched at all, so I do not have an opinion as to how to describe touching an allodynia. But if I have to describe this, it would be "to hurt" the patient.".* Not touching was felt to be important as causing pain through touch may have a negative effect on rapport; *"Desensitizing a person's hand who cannot stand to be touched (case 1) will erode the therapeutic alliance. Need to build trust."* and *"… I decide to use modalities that avoided me as a therapist touching them such as whirlpool, contrast baths, and ultrasound submerged in water. As well, this approach provides them with a locus of control and allows a trust to develop between the patient and me ... that is I am not hurting them.".*

The level of sensitivity was considered important, and when just sensitive, but not allodynic / painful touching was recommended; *"When there is a situation that looks like or is allodynia, then the advice is not to touch. But when it is more sensitive (maybe like baby skin) touching can be helpful."* and *"The therapy of*

allodynia and hyperesthesia differ in principle. In the case of allodynia, the rule is: don't touch. In the case of hyperesthesia desensitization can be used." and *"Desensitisation techniques are once again only used in scenarios where patients can tolerate the input and have a specific type of hypersensitivity, this is also not appropriate for all clients.".* The idea of a "tolerable" amount of stimulation on the area of allodynia was mentioned many times; *"desensitization - hourly to every other hour touch with a sensory stimulus (blanket, towel, massage - whichever patient can tolerate in the clinic) if patient cannot tolerate the desensitization then I would use an app for right/ left laterality training"* and *"Desensitisation techniques according to patients tolerance levels - this is very dependent on what a patient can tolerate in terms of textures and pressure etc.".* The concept of starting outside the area of allodynia and progressing in was suggested and described in detail by some; *"Have the client identify the area that is the absolute worst, record this, then have client identify a circle around that spot that is not to be touched, then have client identify the area that does not feel right, but can be touched, then have client identify a safe zone around this area. Start stimulating the safe zone leading into the next zone. Starting with safe textures seeing if how close we can get to the "not to be touched area". Hoping to try and make this area smaller and smaller over long periods of time."*

This difference of opinion regarding whether touch is desirable, or to be avoided, was highlighted in the discussion of whether an area of allodynia should be covered or not. Participants agreed an area should be left exposed but for

different reasons. Some felt it was best to leave the area exposed as a cover may increase the pain; *"Normally I try not to cover the allodynia area to avoid touch with the zone."* and *"Every stimulus of the allodynic receptor field is increasing the spinal / supraspinal / cortical sensitization of the somatosensory nervous system.".* However, depending on the client, some stated the area should not be covered to allow touch *"The decision to cover an area of allodynia is client specific. If the client can wean from the covering and participate in some use and sensory activities without it on, then I will use it and educate the client why we are weaning from it. However, if the client does not come out of the covering at all then I will encourage discontinuing the covering all together. Rarely have I found I have to do the latter.".*

Chapter 4. Discussion and Conclusions

This thesis examined how terms related to allodynia are used, as well as how allodynia is assessed and treated in hand therapy. To accomplish this a limited literature review was conducted and the Delphi survey technique was utilized to collect the opinions of expert hand therapists. We found support for the IASP's definitions of allodynia and hyperesthesia as they are, with no modifications recommended for the hand therapy context. We also created a new consensus definition for the term hypersensitivity, a term commonly used in hand therapy practice, which had not been previously defined. Recommendations for assessment and treatment were generated by the participants with the caveat that the selection of individual items would depend on the unique presentation of each client. Factors considered important in the selection of these options were the presumed underlying mechanisms contributing to the allodynia, and the psychosocial and functional status of the individual. Whether an area of allodynia should be touched or not was an emergent theme throughout the study and consensus was not reached around this issue. The recommendations generated from this study, along with the literature review, can be used to provide guidance to clinicians until more robust research is undertaken. Research to date has been limited and has focussed primarily on various approaches to tactile stimulation as an intervention for allodynia. (Quintal et al., 2021) Recommendations for future research are presented throughout and summarized at the end of this chapter.

New Definition of Hypersensitivity

The term hypersensitivity is often used in hand therapy practice yet has not been formally defined. Through the consensus process the following new definition of hypersensitivity for use in hand therapy was created; “Increased / heightened sensitivity and response to innocuous stimuli which may be experienced by the client as either painful or not painful”. This new definition is different from several related IASP definitions as presented in table 1 below. There is overlap with already existing definitions however this is not considered problematic as our goal was to define hypersensitivity in the context which it is used in practice.

Table 1

Comparison of New Definition of Hypersensitivity to Current IASP Definitions of Related Terms

	Definition	**Quality of the stimulus**	**Evoked or spontaneous**	**Client experience**
Hypersensitivity (new definition)	Increased / heightened sensitivity and response to innocuous stimuli which may be experienced by the client as either painful or not painful	Innocuous	Evoked	Could be either no pain or pain
Paresthesia *	An abnormal sensation, whether spontaneous or evoked.	Innocuous	Evoked or spontaneous	Abnormal sensation

Dysesthesia * (includes allodynia and hyperalgesia)	An unpleasant abnormal sensation, whether spontaneous or evoked.	Innocuous or noxious	Evoked or spontaneous	Abnormal unpleasant sensation, including heightened pain
Hyperesthesia * (includes allodynia and hyperalgesia)	Increased sensitivity to stimulation, excluding the special senses.	Innocuous or noxious	Evoked	Could be no pain to heightened pain
Allodynia *	Pain due to a stimulus which does not normally provoke pain	Innocuous	Evoked	Pain
Hyperalgesia *	Increased pain from a stimulus that normally provokes pain	Noxious	Evoked	Heightened pain

* = International Association for the Study of Pain definitions

This new definition of hypersensitivity is different from allodynia, as with hypersensitivity the response could be either painful or not, whereas allodynia is always painful. It is also different from hyperesthesia, in that with hypersensitivity the stimulus is innocuous whereas in hyperesthesia the stimulus could be either innocuous or noxious. This definition may benefit from review and updating. There was an almost equal split in preference for the use of the words “sensitivity” and “response” within the definition and it was a compromise to include both. Also, the wording “not painful” is not as specific as “abnormal” because not painful can also include normal, which does not apply in this context.

Hypersensitivity was described in a seminal article (Yerxa et al., 1983, p. 176) on desensitization as *“a condition of extreme discomfort or irritability in*

response to normally non noxious tactile stimulation". Our definition is similar only in that the stimulus is considered non noxious. However, it is different in 2 important ways 1) the generic term stimulus is used (not limited to tactile), and 2) the wording "which may be experienced by the client as either painful or not painful" is used (not "extreme discomfort or irritability"). When the article by Yerxa was written the term allodynia was not yet in use. Although the authors do not use the word "pain", using "extreme discomfort" would suggest perhaps they were referring to what is now considered allodynia.

Therapists could use the new definition of hypersensitivity formulated through this study to refer to a client's experience of either increased sensation or pain, to any stimulus that would normally not be painful. For example, "hypersensitivity" could be used if a client reports that touching their hair, or a towel, feels unusually rough or prickly but not uncomfortable (which could also be called paresthesia). Hypersensitivity could also be used if touching those things were uncomfortable (which could also be called dysesthesia) or painful (which could also be called allodynia). It could also be used for increased sensation or pain to warm or cool temperatures. This new definition of hypersensitivity should not be used for stimuli that would normally be painful such as a pin prick or a pinch; nor should it be used to describe spontaneous or resting pain. A clear definition of hypersensitivity allows us to contrast this with the less familiar IASP terms during knowledge translation activities. Increasing familiarity with the IASP

terms may reduce the use of the term hypersensitivity as therapists become aware of the more precise terminology.

Assessment and Treatment of Pain

A biopsychosocial approach is appropriate when assessing and treating pain, particularly chronic pain. (Adams & Turk, 2018) A biopsychosocial perspective encourages the clinician to consider biological, psychological, social, and contextual factors as contributors to pain (Adams & Turk, 2018). How an individual processes information as well as their unique histories and emotional regulation strategies, contributes to judgments about the meaning of sensory / external events and they develop expectations concerning the consequences of the events. (Moseley, 2003) All these factors influence an individual's pain related responses. Adams (Adams & Turk, 2018) discusses aspects influencing chronic central sensitization pain including cognitive aspects (perceived control, self efficacy, catastrophic thinking, hypervigilance, and fear avoidance), emotional aspects (depression, anxiety, and anger) and social aspects (socioeconomic status, social stigma and skepticism, social learning and operant conditioning, and social support). All these aspects have been shown to mediate and moderate chronic pain to some degree. (Adams & Turk, 2018) The degree to which these aspects may influence pain will vary between individuals and over the lifespan of an individual. (Borsook et al., 2018) The experience of pain and by extension, allodynia is thus influenced not just by sensory signals but by other inputs experienced by the individual as well. Multiple factors may influence the

experience of pain as is described in The Neuromatrix Model of Pain (Melzack, 2001) presented in chapter 1, figure 1.

The Neuromatrix Model was selected to frame the discussion that follows as it brings together multiple potential inputs into the individual: not just the sensory / neurological inputs but also cognitive / evaluative and motivational / affective inputs which can contribute to the processing of pain. It also presents outputs that are more than the perception of pain and include behavioural and physiological stress responses, thus providing a broader understanding of the pain experience. (Moseley, 2003)

The Neuromatrix Model of Pain is helpful when considering the complex relationships between inputs into an individual's system and the consequent outputs in a pain response such as allodynia. For example, a sensory treatment such as tactile stimulation will have cutaneous sensory and visual inputs but may also have cognitive / emotional inputs such as increased attention or anxiety that may modulate pain perception and behavioural response. Treatments such as mindfulness meditation will have a cognitive input that may interact with motivational / affective inputs such as the current stress hormone levels that interact to produce a unique output for that individual.

Assessment of Allodynia and its Impact

Some assessment recommendations were specific to assessing the sensory component of allodynia (types of allodynia [i.e., modality inducing allodynia], intensity, size and location of the allodynic area). Other

recommendations related to the overall assessment of areas considered important but not specific to the sensory component of allodynia.

Assessments Specific to the Sensory Component of Allodynia

Assessment for Types of Allodynia – Mechanical and Thermal. Survey participants recommended assessing for static mechanical allodynia through response to light touch on the area of allodynia. For cold allodynia, asking the question “is there difficulty with exposure to cold” was recommended. Assessment for the different types of allodynia is presented in the textbook Handbook of Pain Assessment (Katz & Melzack, 2011) and in a review article (T. Jensen & Finnerup, 2014). See chapter 1, table 1 for a summary.

The limited literature review found 9 hand therapy studies assessing mechanical allodynia (see chapter 1, table 3). Of these studies, 7 assessed static mechanical allodynia, one (Lewis et al., 2011) assessed either static or dynamic depending on patient tolerance, and one study focused on dynamic mechanical allodynia (Love-Jones et al., 2009). Our study findings are consistent with this small amount of research showing a preference for the assessment of static mechanical allodynia.

Survey participants recommended asking about difficulty with exposure to cold but did not recommend a physical assessment of tolerance or a standardized self report to use. The Cold Intolerance Symptom Severity questionnaire (CISS) (Ruijs et al., 2006), which is an updated version of the Cold Sensitivity Severity Scale (S. McCabe et al., 1991) was suggested but did not

reach consensus. Despite the potential impact on occupation and life roles (Carlsson et al., 2010) there is very little research on intervention for thermal allodynia. One study (Vaksvik et al., 2016) concluded that their preliminary results from 22 individuals with “cold hypersensitivity” suggest classical conditioning has the potential to reduce symptoms and should be further explored.

The underlying neural mechanisms are different between the types of allodynia (see chapter 1, table 1). Thermal allodynia is transmitted via sensitized nociceptors. Static and dynamic mechanical allodynia are transmitted primarily via Aβ mechanoreceptors. (Devor, 2013) Arguably, in the course of day-to-day activity, mechanical allodynia will have a greater impact on function than thermal allodynia, as pain with touch limits individuals handling objects thus reducing functional use of the hand. A focus on the assessment of mechanical allodynia (both static and dynamic) would be helpful in future intervention studies (unless the intervention is specifically for thermal allodynia). If available, quantitative sensory testing (QST) (Rolke, Magerl, et al., 2006) for assessment of dynamic mechanical allodynia and the Rainbow Pain Scale (RPS) to identify and quantify the intensity of static mechanical allodynia (Packham et al, 2019) is recommended.

Quantitative sensory testing (QST) is recommended for the assessment and monitoring of allodynia by the Neuropathic Pain Special Interest Group of the IASP. (Backonja et al., 2013) QST is different from common clinical assessment of allodynia in that the stimuli are calibrated and delivered in accordance with

specific testing algorithms, and standardized instructions are utilized. QST is helpful to detect dynamic mechanical allodynia, which may discriminate patients with or without neuropathic pain. (Backonja et al., 2013) However, for dynamic mechanical allodynia, stimulus parameters vary widely and there is no consensus regarding stroke number, length, duration, velocity, frequency, or interstimulus intervals. (Walk et al., 2009) QST is based on the hypothesis that a decrease or increase of perception and pain thresholds suggests the underlying neurobiological mechanisms (Backonja et al., 2013). This view, specifically for allodynia, has been questioned (Keizer et al., 2008) with the authors stating that with current QST approaches it is not possible to distinguish between nociceptors and mechanoreceptors. The full QST test battery utilized by the German Research Association for Neuropathic Pain assesses 13 parameters in 7 test procedures. (Mücke et al., 2021; Rolke, Magerl, et al., 2006) Mechanical testing includes; detection thresholds (via monofilaments), pain thresholds (via pin-prick), pain sensitivity (via pin-prick interspersed with cotton wisp, cotton wool tip, and brush for dynamic mechanical allodynia), wind-up ratio (via pin-prick), vibration detection threshold (via 64 Hz. tuning fork), and pressure pain threshold for deep pressure (via an algometer). Thus, static mechanical pain sensitivity is tested via pin-prick and blunt pressure / algometer. Testing for the presence or intensity of static mechanical allodynia is not part of the battery. In a review of nonautomated QST for neuropathic pain (Walk et al., 2009) the use of monofilaments to assess for punctuate (static mechanical) allodynia is discussed but is not included in the

final battery which, for mechanical stimuli, included use of a soft brush, pin, algometer, and tuning fork. (Wasan et al., 2020) Thus, dynamic mechanical allodynia is included in these influential QST protocols, but static mechanical allodynia is not.

Assessment for Intensity of Static Mechanical Allodynia. Assessment of static mechanical allodynia through response to static light touch was recommended by survey participants as a quick method to screen if allodynia is present. However, it does not allow for grading of severity, or for noting degrees of improvement. Pressure pain threshold testing (PPT) including testing with an algometer, or monofilaments were suggested but did not reach consensus. An algometer can be used to quantify and track pain although is generally considered for use in assessing sensitivity of deeper tissues not skin (Kinser et al., 2009). Use of monofilaments to assess severity of allodynia is common in research (Dros et al., 2009) but does not appear to be common in clinical practice. Of the monofilament approaches suggested by participants the RPS was most supported, although not enough to reach consensus. The RPS (Packham et al., 2019; Spicher, Barquet, et al., 2020) uses seven graded monofilaments from the Semmes Weinstein monofilament set to categorize the severity of the allodynia. Evidence suggests (Packham et al., 2019) at least moderate test-retest reliability (intra-class correlation coefficient (ICC) 0.87 n=28, $p< 0.001$) and inter-rater reliability (ICC 0.78, n=31, $p<0.001$). This method utilizes monofilaments that are commonly available in hand clinics. While this

method seems promising in the assessment of static mechanical allodynia it is not widely known, and further research has been recommended. (Packham, 2016) Grading the severity of the allodynia, which is integral to the RPS, would be helpful in future research to help determine if individuals with varying degrees of severity may respond differently to different interventions. Many comments by participants suggested that the severity / intensity of the allodynia would influence their approach to treatment. The RPS is currently the only standardized approach to the grading of static mechanical allodynia with reliability testing. Although it was not endorsed by survey participants, it should be considered in future research.

A VAS or NRS in response to touch, as has been used in desensitization research to date, and / or self report questionnaires for neuropathic pain may add depth in future research, but the use of these as the only research outcome for allodynia is not recommended as they may not capture allodynia comprehensively.

Assessment for the Location and Size of the Allodynic Area. Survey participants recommended three approaches to consider for assessing and noting the location of allodynia. These were a) clinician drawn using the SRM protocol of allodynography (Spicher, Barquet, et al., 2020), b) client drawn on a hand or body diagram, and c) described in words in chart notes based on the client's description. Of the 9 studies found, 4 mapped the area of allodynia using allodynography (Nedelec et al., 2016; Packham, Spicher, et al., 2018; Quintal et

al., 2018; Spicher et al., 2008). Two (Lewis et al., 2011; Love-Jones et al., 2009) used a 2 cm grid marked on the skin and the allodynic area was mapped by brushing with a cotton bud. One study measured the area drawn by the client (Göransson & Cederlund, 2011). The remaining two studies (Menck et al., 2000; Sweeney & Harms, 1996) described the area. Using a standardized approach, such as allodynography or a grid system, allows for more accurate assessment of the size and location of the allodynia. Shrinkage of an allodynic area (Love-Jones et al., 2009) and shifting distally (Lewis et al., 2011) has been reported following hand desensitization programs. Preliminary evidence for allodynography, with small sample sizes shows excellent inter-rater reliability (ICC 0.97, n=12, $p<0.001$) and test-retest reliability (ICC, 0.89 n=10, $p<0.001$) for this approach. (Packham et al., 2020)

An expansive area of allodynia is thought to be suggestive of greater central sensitization (Woolf, 2018). However, the results of a study of SRM for allodynia in individuals with CRPS (Packham, Spicher, et al., 2018) did not support the concept of a larger area of allodynia being associated with greater pain. The authors found that individuals with a single area had more pain $p=0.03$, and when comparing the adjusted area of allodynia to the severity of allodynia as measured using the RPS, the results, although statistically significant, were not considered clinically meaningful. If the expansiveness of the area of allodynia is not a reliable marker of greater central sensitization, then perhaps other metrics should be considered. Summation and the widespread features catalogued by

the Central Sensitization Inventory (Cuesta-Vargas et al., 2020; Mayer et al., 2012) may help to determine the degree of central sensitization and help determine which treatments are effective when there is greater central sensitization.

Other Areas of Assessment Considered Important

In addition to assessing the sensory aspects of allodynia as described above, participants recommended considering assessing resting / spontaneous pain, factors which may influence pain, functional status, physical status, psychosocial status, screening for CRPS using the Budapest criteria, and assessment for a central component contributing to the pain. Collecting information through the use of interview, patient reported outcomes measures, observation, approaches to assess cortical representation, and hands on assessment were recommended.

Participants recommended five questionnaires for pain and function, see table 4 in chapter 3. Related to pain were the Douleur Neuropathique 4 (Bouhassira et al., 2005) the McGill Pain Questionnaire (Dworkin et al., 2009; Melzack, 1975) and the Pain Catastrophizing Scale (Sullivan et al., 1995). Related to the assessment of function participants recommended the Patient-Rated Wrist/Hand Evaluation (MacDermid, 2019) and the Patient-Specific Functional Scale. (Stratford et al., 1995). Participants also recommended that when using self-report questionnaires for function, both an assessment of upper extremity function with standardized items and an assessment of client-identified

important items be used. Five of the nine studies in the literature review used a self-report measure, see table 3 in chapter 1. Three of these (Nedelec et al., 2016; Packham, Spicher, et al., 2018; Quintal et al., 2018) used the Questionnaire de la Douleur Saint-Antoine (QDSA) (French version of the McGill Pain Questionnaire (MPQ)). One used the Canadian Occupational Performance Measure (Göransson & Cederlund, 2011) and one the Canadian French version of the Disabilities of the Arm Shoulder and Hand. (Quintal et al., 2018) There appears to be agreement between study participants and the limited literature, that use of a patient reported outcome measure for pain is appropriate with the QDSA / MPQ recommended by participants and used in research. To help capture the functional impact of allodynia, future research may benefit from including a validated assessment of upper extremity function with standardized items, and a validated assessment of client-identified important items if these are available in the language of the study.

The Neuromatrix Model of Pain suggests cognitive / evaluative inputs are important in the experience of pain and may influence the pain experience. Thus, assessing for these may help determine who may benefit from various approaches. Assessment for factors which may influence response to tactile stimulation may include the psychological variables of pain catastrophizing using the PCS, (Sullivan et al., 1995); an assessment for anxiety may help predict who may respond to treatment.

Five of the nine literature review studies (see chapter 1, table 3) also included some form of physical assessment. Two assessed range of motion and one assessed strength. In our survey active range of motion of affected and unaffected joints was recommended but assessment of strength was not. Three studies assessed two-point discrimination, and two evaluated pressure perception thresholds. In our survey both these types of assessment had low support and were not included in the final recommendations. One study assessed for neural tension and used neural mobilization as the treatment for allodynia. Participants in our study did not recommend assessing neural tension although it was voted on in rounds two and three. Assessing for nerve compression was also explored in our survey and in round two this almost reached consensus with 73% (33/45) support but did not reach consensus in subsequent rounds and was dropped.

Two studies in the literature review assessed cortical functions related to body perception in individuals with CRPS experiencing allodynia. A case study (Quintal et al., 2018) assessed for left / right recognition, the other (Lewis et al., 2011) assessed the extent of body perception disturbance in four individuals with CRPS (2 upper extremity) using the Bath CRPS Body Perception Disturbance Scale. (Ten Brink et al., 2021) Allodynia is often seen in association with CRPS. (Birklein et al., 2000; Dietz et al., 2019; Gierthmühlen et al., 2012) and in those with CRPS greater parietal lobe dysfunction was more associated with a larger area of allodynia. (Cohen et al., 2013) Assessment for altered cortical

representation of the limb via laterality recognition, (Moseley, 2004) or the use of a mirror (Acerra & Moseley, 2005) have been studied with individuals with CRPS. The use of these evaluations in CRPS, a condition that often presents with allodynia, may explain the high support for assessment of cortical representation of the limb in our study. Further research is needed to determine if cortical representation of a limb is altered in individuals with allodynia who do not have a diagnosis of CRPS.

Treatment of Allodynia and its Impact

Broadly grouped, recommended interventions for allodynia were sensory (including tactile stimulation), other physical, and “top down” which included functional interventions, techniques to alter cortical representation, education, support, and psychosocial interventions (for details see table 6 in chapter 3). Interestingly, it was treating the impact and psychosocial aspects that were the most quickly and strongly agreed upon in the study. For example, participants supported functional interventions such as activity modification and promoting functional hand use, and psychosocial interventions such as mindfulness meditation, cognitive behavioural therapy, and education. Research within the specialty of hand therapy often focusses on the impairment level of function, (Burley et al., 2018; Takata et al., 2019) however our results suggest a broad focus on participation.

The options recommended are congruent with a biopsychosocial approach. Making decisions while considering the psychosocial status of the

individual was a theme of the study and fits well within the Neuromatrix Model of Pain. In contrast, the literature review showed a main focus on tactile stimulation with eight of the nine studies using some form of tactile stimulation as the intervention (one of these also used spinal manipulation (Menck et al., 2000)). The remaining study used nerve mobilization as the intervention. (Sweeney & Harms, 1996)

Tactile Stimulation as a Treatment for Allodynia

While tactile stimulation received high support in our survey and is the main object of research in the literature, the approach is not agreed upon. A point of disagreement during the study was whether it is helpful or not to touch an area of allodynia. This disagreement influenced many treatment recommendations including how to approach tactile stimulation. Approaches to tactile stimulation included touching directly on the area of allodynia, touching next to and grading textures and working towards the allodynia, and counterstimulation used as part of SRM. It is important to note that this lack of agreement in approach reflects not only the broader literature which includes conflicting viewpoints, but even a lack of clarity in published treatment guidelines. For example, the most recent guidelines for CRPS from the UK (Goebel et al., 2018) include recommendations for desensitization in an appendix. The instructions give several examples of direct stimulation on the affected limb using the wording “applying to the affected area” but then also direct the individual to apply various textures by starting in an

area where touch is tolerated and moving towards the area where it is not tolerated. (Goebel et al., 2018)

Of the 8 studies using tactile stimulation in the literature review 3 followed the SRM protocol, 1 used the SRM protocol plus graded motor imagery, and the remaining four used desensitization with touching directly on the painful area. A review of these studies found them to be of low quality. (Quintal et al., 2021) It is not yet clear which, if any, of these tactile stimulation approaches can be endorsed as an effective treatment for allodynia.(Quintal et al., 2021)

When the skin on the hand is touched gently and an individual experiences pain, the nervous system from the hand to the cortex is involved. Allodynia requires a peripheral stimulus, receptors to pick it up, nerves to carry the messages, the spinal cord to sort and relay, descending control from the brain, and the brain itself to perceive the pain. (Finnerup et al., 2021) The question is, at what level(s) have things gone wrong, and what can we do to help normalize the system? The Neuromatrix Model of Pain suggests multiple inputs are going on simultaneously during a painful experience. When allodynia pain is evoked, either by the individual through touch or use, or by a therapist's touch, there are sensory-discriminative inputs (cutaneous and visual), cognitive-evaluative inputs (attention, expectation, mood, past experiences), and motivational-affective inputs (hormonal, immune and limbic system activity). These inputs all influence the perception of pain, as well as the behavioural and

physiological responses. Ultimately, regardless of the peripheral input, pain is processed in the brain. (Elliott & Barbe, 2021)

As allodynia seems primarily driven by peripheral input, it makes intuitive sense to attempt to alter this input by changing the tactile experience of the individual. As pain is processed in the brain it also makes sense to consider the other inputs, not just the tactile sensory input, that may influence the experience of pain such as the visual sensory, cognitive-evaluative and motivational-affective inputs.

Clearly articulating and testing the theories upon which interventions are based is recommended. (Craig et al., 2008) Proponents of touching directly on an area of allodynia suggest that nerves will “accommodate” to the stimulation (Wietlisbach, 2020) although the mechanism allowing the accommodation is generally not explained. Only one author (Love-Jones et al., 2009) suggested a mechanism i.e., that Aβ fibres, in addition to contributing to allodynia, in some individuals may also engage in segmental inhibitory activity producing an effect that narrows the size of the afferent field from which allodynia can be provoked.

Touching near an area of allodynia and moving in towards the area of pain appears to rely on the same theory of “accommodation” although this is not a painful treatment (at least initially) and perhaps a sense of control is developed. With this approach elements of sensory reeducation (such as attention and discrimination compared to the unaffected hand) (Lewis et al., 2011) may be promoted when stimulating outside the allodynic area.

The SRM approach recommends avoiding contact with the allodynic area plus comfortable stimulation in a distant anatomically associated cutaneous nerve distribution. (Spicher, Barquet, et al., 2020) SRM is thought to be effective by 1) allowing neurotransmitters, generated from comfortable stimulation in an anatomically related nerve branch to reduce the aberrant signalling in the spinal cord and 2) by avoiding tactile stimuli to the area of allodynia in therapy and daily activities so there is less input to maintain the maladaptive neuroplasticity contributing to the allodynia. (Spicher, Barquet, et al., 2020) Treatment is not painful and can be done primarily as a home program. Integral to this approach is avoidance of touch to the area of allodynia in therapy and in daily activities which is a significant departure from the historical use of “desensitization”. It is worth considering whether it is the careful avoidance of touch / stimulation, the “counterstimulation” or the combination of both, that is the active ingredient in this approach.

Treatment of Allodynia Using “desensitization” via touching directly on an area of allodynia. Desensitization was described in a seminal article (Yerxa et al., 1983 p. 178) as *“decreasing the sensitivity of the hand to an external stimulus”.* Direct stimulation using textures, immersion, and vibration was described. Recently an updated definition of desensitization (Packham, 2021, p. 67) was put forward: *“desensitization is a strategy to control or change sensory and/or nociceptive inputs to modulate sensory processing and thus the perceptual experience via direct stimulation to an area of unpleasant cutaneous*

dysesthesia. These inputs can be tactile, thermal or proprioceptive, and the intended target of modulation is both at the spinal level (dorsal horn) and memory and emotional centres in the brain."

The meaning of the term "desensitization" was explored over the survey rounds. Of those with an opinion, 81% agreed that touching directly on an area of allodynia is best described by the term "desensitization". However, in a separate question 52% also indicated that touching near is best described by the term "desensitization". Most of the comments in response to the terminology questions expressed opposition to touching an area of allodynia, as it is painful, and did not comment on terminology. This lack of agreement on terms may have an impact on the interpretation of past research or on future research and reviews as these terms are not applied consistently. More work is needed to reach an agreement on the meaning of desensitization. Both the literature review and this study demonstrated a lack of consistent use of the term "desensitization" showing it can mean touching directly on, touching near an area of allodynia, or a transition from near and progressing into the area of allodynia. The few studies that have been done have been of low quality (Quintal et al., 2021) The differences in these approaches is important as touching on the area is painful, and touching near is not. If a non painful approach is as effective, or more effective, then this would be preferable. As historically, desensitization has meant touching directly on the area of allodynia, and this was more endorsed by survey participants, perhaps only touching directly on the area should be retained as the meaning of

desensitization. Consensus could be sought on a different term to describe non-painful touching near an area of allodynia so that these two different approaches can be contrasted and compared to better understand if, how, when and for whom they provide benefit.

Desensitization has its roots in the treatment of “hypersensitivity” of traumatized hands (Barber, 1990; Hardy et al., 1982; Yerxa et al., 1983) with the hypersensitive area being directly touched with textures, immersion, and vibration. Desensitization was recommended often by study participants in round one although the location of the stimulation was most often not stated. It is a treatment recommended in hand therapy texts (Rosen et al., 2021; Stralka, 2020; Walsh, 2011) and CRPS practice guidelines. (Goebel et al., 2018) There is conflicting advice on how desensitization should be carried out, which is unsurprising given that the term is used to describe the approaches previously discussed.

The term “tolerable” is often used i.e., advice is given to “touch the allodynic area with a ‘tolerable’ stimulus”. The study by Gorannson (Göransson & Cederlund, 2011) recommended using a texture that was “barely tolerated” whereas the stimulus was referred to as “slightly intolerable” in a hand therapy text. (Rosen et al., 2021). Lewis (Lewis et al., 2011) recommended “tolerated” textures, and used a NRS to rank them but did not provide the ranking information or suggest a cut off for how much pain was acceptable. Several survey comments suggested touch may be more helpful with “uncomfortable”

dysesthesia than with “painful” allodynia. Thus, a thorough assessment and understanding of the degree of pain is important. Comparison of future studies would be improved if an acceptable level of pain increase was described and quantified perhaps using a NRS. For example, pain should not go above a 3/10 or increase on touch more than 1 point on a NRS (or whatever level the researcher deems appropriate). This approach to numerically quantifying could replace terms such as “tolerable” which may have variable interpretations.

The idea that touching on an area of allodynia may be more helpful when the allodynia is due to peripheral sensitization was explored. This concept did not meet consensus. However, in round four two thirds of participants agreed that touching directly on the area may be helpful. Peripheral sensitization is driven by hyperactivity in nociceptors.(Devor, 2013) In comparison to central sensitization the area of allodynia is small (Woolf, 2018). However, the German Research Association for Neuropathic Pain (Mücke et al., 2021) posits that in peripheral sensitization allodynia sensitivity is unchanged or the phenomenon is not examinable suggesting peripheral sensitization is not an underlying neurobiological mechanism. As there is disagreement on this issue, this concept needs further exploration.

The largest study of desensitization that assessed for allodynia (Göransson & Cederlund, 2011) included 39 individuals with pain / discomfort at or around a scar from an injury or surgery (thus a small area of allodynia). A decrease in pain on stroking the area with the other hand was one of the

inclusion criteria for the study which likely biased the outcome as only those who responded on screening were included. The study found a significant decrease in VAS (from 73 to 51) for touch evoked pain after 6 weeks of a home program of desensitizing with a texture that was “barely tolerated” on the painful area. The authors indicated that of the 39 patients, 10 had mainly nociceptive pain, 16 had neuropathic pain and 13 had pain of mixed origin. Three of the four individuals who had an increase in pain had neuropathic pain and those with nociceptive pain had greater pain reduction. The authors suggest that hyperaesthesia from nociceptive pain may be more responsive to treatment. In a separate retrospective study (Chu et al., 2001) of treatment including desensitization following fingertip amputation, resting pain at the stump remained in 11 of the 25 individuals after an average of 5.3 weeks of treatment. Evoked pain / allodynia was not commented on. Both of these studies of desensitization included individuals with a localized area of pain (scar and fingertip) and the study by Goransson excluded individuals with CRPS suggesting these studies of desensitization through direct touch on the area were conducted with individuals with peripheral sensitization driven more by nociceptors. These studies add to the evidence supporting the use of direct touching on an area of allodynia when peripheral sensitization is suspected.

It is sometimes difficult to determine if pain is nociceptive or neuropathic and it has been suggested that it is possible to indicate whether neuropathic pain is in the categories of “possible”, “probable”, and “definite”. (Finnerup et al., 2016)

This would be more appropriate than an all or nothing rating. (Bennett et al., 2006). The use of the assessment Douleur Neuropathique 4 (Bouhassira et al., 2005) was recommended by participants and is available in French and English. This assessment can be used to help determine if pain is neuropathic vs. nociceptive and may help identify who may respond to desensitization treatment.

Somewhat counterintuitively painful stimulation has been shown to reduce the size of an area of allodynia but not the pain intensity. A small number of studies show that both heterotopic (Witting et al., 2003) (meaning a distant location) painful cold exposure, and homotopic (Love-Jones et al., 2009) (meaning in the same location) painful brushing stimulation have shown association with a reduction in the size of an area of allodynia in individuals with neuropathic pain. In a study (Love-Jones et al., 2009) of painful dynamic stimulation with a cotton bud (activating mechanoreceptors) shrinkage of the allodynic area was more extensive than a comparably painful heat stimulus (activating nociceptors). The authors found no predictive factors in who may respond to the dynamic stimulation. They suggest that shrinkage in response to stimulation of the area may be used as a screening test to identify patients that may benefit from a graded program of desensitisation as opposed to those better served by avoidance of stimulation. Thus, it is recommended that if future studies evaluate the effectiveness of touching on an area of allodynia, they include an outcome measure for the size of the area and assess if predictive variables can be identified such as baseline pain level, duration of pain, or extent of the area.

Clinicians may benefit from watching for a shrinkage of the area. If a shrinkage is observed, then persisting with direct desensitization may be more likely to help but more research is needed to confirm and better understand this response.

An important issue is whether desensitizing through touching on an area of allodynia is appropriate when the allodynia is associated with CRPS. Touching "on the affected area" as well as "working from an area that you can tolerate towards the more uncomfortable skin areas" are both recommended in the UK CRPS practice guidelines. (Goebel et al., 2018) However, the most recent edition of the text Rehabilitation of the Hand and Upper Extremity (Packham & Holly, 2021) recommended against touching on the area. Survey participants indicated direct desensitization on an area of allodynia is not appropriate when the allodynia is centrally driven, and cortical changes are felt to be contributing to the client's pain. Participants endorsed the statements "consider more central treatments if allodynia is part of the diagnosis of CRPS" and "consider being more cautious to avoid pain increase if allodynia is part of the diagnosis of CRPS", and "If the allodynia is felt to be more due to central drivers, direct desensitization on the area is not appropriate and treatments that focus on altering cortical representation of the limb are more appropriate". Based on these statements touching an area of allodynia that is associated with CRPS is not advised. This recommendation can be used to clarify the lack of guidance in the current clinical practice recommendations for CRPS, (Goebel et al., 2018) which fail to provide definitive guidance on whether to touch on, or away from the area.

The cognitive-evaluative inputs as described by the Neuromatrix Model of Pain may be worth considering as predictive variables in research or as factors to consider in the context of whether it may be helpful to touch directly on an area of allodynia. The careful consideration of the client's beliefs / perspective / emotions surrounding the pain may help to determine if this is an appropriate treatment to consider. (Walton & Elliott, 2020) How the clinician and client communicate about pain may shape the client's experiences and influence the outcomes. (Henry & Matthias, 2018) If the stimulation is self applied and progression decisions are left to the client, perceived control may be increased, and a sense of self efficacy may influence pain perception. (Bandura, 1990; Litt, 1988) These points could be made regarding any therapy technique however, in the context of a treatment that is painful, it seems even more important to keep in mind.

To aid in the discussion of whether it may be beneficial to touch an area of allodynia or not, table 2 presents this author's application of the Neuromatrix Model of Pain to touching an area of allodynia.

Table 2

Neuromatrix Model of Pain applied to touching an area of allodynia.

INPUT	Touching may be helpful	Touching may be unhelpful	Clinician to consider
Cognitive - evaluative Past experience and personality inputs. Level of anxiety, attention, and	Client may have a "no pain no gain" perspective and touching the area may considered a "good pain"	Client may have had negative past experiences with pain / therapy. Anticipating touching may reinforce anxiety and stress	What are the client's cognitive and affective states? - perspective on touching the area?

expectation of pain with touch			-past history with pain?
Sensory – discriminative Sensory input activates Aβ fibres Visual input of hand getting touched	Activating Aβ fibres may allow them to "accommodate" Visual input may bring positive attention to the hand	May reinforce already overactive connections from Aβ to nociceptors in the spinal cord. Visual input may increase anxiety	What is the client's physiological state? -severity of allodynia -is the allodynia territory expansive (suggesting more central sensitization)
Motivational – affective Cytokines, stress hormones, and / or limbic system activity	Low levels of stress systems activity have a positive influence during a painful experience	High levels of stress systems activity have a negative influence during a painful experience	What is the client's affective state? -are stress hormones / cytokines likely low or high?
OUTPUT	**Touching may be helpful**	**Touching may be unhelpful**	**Clinician to consider**
Pain perception Cognitive-evaluative Sensory-discriminative Motivational-affective	Positive evaluation of touching may contribute to descending inhibition and reduce pain	May increase attention, stress, and anxiety around touching hand. May "wind up" pain pathways	What is the pain response to touching? (cognitive, sensory and affective)
Action programs Involuntary action Voluntary action Coping strategies	May increase spontaneous and intentional use	May pull hand away, reduce use of hand, reduce attendance in therapy or adherence to home exercises	What behaviours are observed? -engaged or fearful -effect on hand use
Stress regulation Stress hormones, immune activity, endorphin levels	May reduce fear of touch and reduces stress systems activity	May increase fear of touch and activate stress systems activity	Does touching appear to stress or motivate the client?

Treatment of allodynia using "desensitization" via touching near but not on an area of allodynia. Touching on non-painful skin around an area of allodynia is often referred to as "desensitization". Our survey results indicated that, of those with an opinion, 52% (16/31) felt touching near an area of allodynia is best referred to as desensitization and 36% (11/31) felt sensory relearning was the preferred term for this. Touching on non painful skin has very different neurological effects compared to touching on painful skin. Touching non painful skin stimulates Aβ mechanoreceptors that are connecting to their usual route within the spinal cord (Schwartz & Krantz, 2016) (not to nociceptive pathways). Nociceptors are not activated when touching skin outside the allodynic area and there is no cortically registered pain experience. Touching around the area of allodynia is sometimes combined with sensory reeducation strategies such as attention and discrimination (Lewis et al., 2011) which was recommended in our survey. This approach was the most frequently selected form of "desensitizing" recommended by participants i.e., "touch next to / around but not on the painful area, grade textures, move towards allodynia". This approach is found in a CRPS practice guideline (Goebel et al., 2018) and textbooks (Stralka, 2020) Despite being the most frequently recommended approach to desensitizing by survey participants, none of the four "desensitization" studies in the literature review started outside the allodynic area. The study by Lewis (Lewis et al., 2011) was the closest to the gradual moving in toward the allodynia approach, but the stimulation appears to have been on the periphery but within the allodynic area.

The author describes beginning with the most tolerated texture on the unaffected limb in an equivalent area to the allodynic area. Then, while attending to the sensation the texture was placed or stroked on the allodynic area. The treatment was progressed by increasing the duration of stimulation, moving distally into more allodynic areas, and adding more challenging textures.

It is often unclear what level of pain increase is considered acceptable, where to touch, and how to progress. In a recent practice survey of 132 professionals who treat CRPS (Miller et al., 2019) ”desensitization” was reported to be used “always / frequently” by 67%. However, a definition of desensitization was not given. Given the literature and our results some may have interpreted “desensitization” to mean touching around (not painful) and other may have interpreted it to mean touching directly on the area (painful). The UK CRPS practice guidelines (Goebel et al., 2018) provide a detailed appendix for clients on desensitization which describe the level of pain that is considered acceptable but is not clear on the location of stimulation. The level of pain increase allowed is described as *“uncomfortable and somewhat painful during and shortly afterwards”* including, *“if you experience intolerable pain and discomfort, then stop that activity and find one that is more tolerable.”* The recommended location of stimulation is not consistent. The examples of incorporating desensitization into several daily activities provide instructions to directly touch the painful area. However, in the section on using textures, the client is instructed to work *“from an area that you can tolerate towards the more uncomfortable skin areas, for*

example from the top of the arm towards the hand.", and to choose textures that are *"tolerable".* If progression from touching non-painful areas to painful areas is the goal in future research, then indicating that this transition is planned and stating what criteria were used to determine when the transition from non-painful to painful is recommended.

Treatment of Allodynia Using SRM. The SRM concepts of avoiding touching an area of allodynia, and comfortable counterstimulation in an associated cutaneous nerve branch, were voted on but did not reach consensus agreement. There is limited yet promising research on SRM. A retrospective cohort study (Packham, Spicher, et al., 2018) of 48 individuals with CRPS who had been treated with SRM at the Somatosensory Rehabilitation Centre in Switzerland, showed a reduction in allodynia and improvements in scores on the Questionnaire Douleur St. Antoine (QDSA – French version of the McGill Pain Questionnaire). Upon completion of treatment the average QDSA score was 20, down from a baseline of 48 (effect size Cohen's D = 1.64). Average length of treatment was 81 days. Allodynia was completely resolved in 27 individuals (56% of the total sample where only 58% completed treatment). Spicher, who developed SRM, reported (Spicher et al., 2008) on 43 individuals from the same treatment center with resolved static mechanical allodynia (SMA). Excluded from the results were 39 individuals who did not meet the inclusion criteria of having resolved SMA (22 stopped treatment, and 17 continued to have SMA at the time of analysis). The author describes an underlying hypoesthesia in all cases and

presents the length of time taken for the SMA to decrease through the stages of the RPS. On average, a period of 70 days +/- SD 66 days (range: 8–206 days) of treatment was necessary for SMA to resolve. In a case series of individuals post burns, (Nedelec et al., 2016) the majority of patients (13/17 or 76%) showed substantial improvements after SRM. In a case study (Quintal et al., 2018) of an individual with long term CRPS, SRM and GMI were used initially with eventual resolution of allodynia. Further research comparing SRM to other forms of tactile stimulation treatment for allodynia would be helpful and the research agenda needed to close the knowledge gap has been well described. (Packham, 2016) SRM is more accessible in the French language at this time and requires 35 hours of dedicated training to obtain certification, which are barriers to its dissemination. Uptake into practice, and research of SRM, would be enhanced by an English translation of the most recent French text, (Spicher, Barquet, et al., 2020) and more accessible training in other languages including English such as through an online self study program

Other Interventions Considered Important

Peripherally Focussed Interventions. Participants recommended approaches to reduce edema and improve movement in the presence of allodynia, nerve gliding in the presence of neural tension and allodynia, soft tissue work / mobilization / scar massage, and TENS. Of these recommended options, only nerve mobilization (Sweeney & Harms, 1996) was evaluated 26 years ago. In this uncontrolled study 25 out of 29 subjects with mechanical

allodynia presented with an abnormal upper limb tension test that biased the median nerve. All subjects had not improved with a prior desensitization program of touching on the area. Prior to treatment twenty-two subjects reported allodynia symptoms during tensioning of the nerve (with no mechanical stimulation to the allodynic area). Subjects' hand injures included amputation (23), carpal tunnel release (2) and laceration (4). Participants were taught a home program of neural tension exercises to do once a day. Reassessment at two-weeks showed pain in response to gentle pressure with the blunt end of a pencil on the area of allodynia was less in 20 participants, more in two, and unchanged in 7. The authors concluded that a home mobilization exercise program can offer substantial improvement in symptoms to individuals with mechanical allodynia and recommended further research. Participants in our survey supported nerve gliding as a possible treatment for allodynia in the presence of neural tension. Mobilization of tissues and scar massage was also recommended. Research is limited in this area. A 2020 meta-analysis (Deflorin et al., 2020) of physical management of scar tissue found nine studies that assessed pain (not specifically allodynia), two of these used scar massage post burns with positive effects. The study by Menck (Menck et al., 2000) also adds to the concept of improving the environment in which nerves function. This case study describes a reduction in CRPS signs and symptoms, including allodynia, following manipulation of the thoracic spine. An interesting avenue of research worth pursuing is evaluating if an improvement to the environment in which nerves

function can contribute to the reduction of allodynia (through edema reduction, increased range of motion, mobilization of tissues and, mobilization of the nervous system itself).

Transcutaneous electrical nerve stimulation (TENS) was recommended as a treatment option, but electrode placement was not agreed upon. The literature review found no studies evaluating TENS as a treatment for allodynia. A 2017 Cochrane review (Gibson et al., 2017) of TENS for neuropathic pain in adults (excluding individuals with CRPS or fibromyalgia) concluded it is impossible to confidently state whether TENS is effective in relieving pain when compared to sham TENS for neuropathic pain. The quality of the 15 studies reviewed was considered very low and further research recommended.

Functional Interventions. Hands are integral to daily function, work, and leisure. When pain limits the ability to touch, hold, and manipulate, functional use is impacted. Hands are used to get washed and dressed, cook and eat, touch, gesture, or communicate allowing participation in life roles. Limitations of the hand can affect a person's life in profound ways. (Wietlisbach, 2020) In this way allodynia of the hand is particularly important and different from allodynia on other body areas such as the trunk or upper arm which would likely have a lesser impact on daily activities and participation in life roles. In addressing the importance of function, participants recommended a) modifying activities / use of assistive devices, b) promoting hand use in meaningful activities and ADLs, c) graded exposure to activity, and d) the use of gloves or splints for specific

reasons (including for temperature control, protection from vibration or for neurological deficits). Covering the area with a glove / splint / gel etc. was also recommended if it improved functional use of the hand although in general, covering an area of allodynia was not recommended.

Although participants agreed that function was an important area of intervention the approach to improving function differed. Some recommended the hand be used as much as tolerated, with touch of the allodynic area through use being seen as desirable and helpful to desensitize. Some participants recommended that touch be avoided, as touch through use would increase input into the somatosensory, spinal, and supraspinal nervous system and perpetuate the allodynia. The latter approach is integral to SRM. (Spicher, Barquet, et al., 2020) No research was found that compared promoting touch through use vs. avoiding touch and modifying activities to limit touch specifically for allodynia. However, in a randomized controlled trial (den Hollander et al., 2016) of 46 individuals with CRPS1 with at least moderate levels of pain-related fear, exposure to daily activities was shown to be more effective than a protective pain-contingent approach in reducing self-reported disability. Whether a therapist should promote use of the hand including touch of the allodynic area, or should be advising the client to avoid touch, is an important question. Research comparing touch vs. avoidance of touch and considering psychological variables is needed to clarify which approach is more likely to benefit individual clients.

An interesting difference in approach to treatment between the three vignettes in round one was the suggestion to cover the area of allodynia. Covering was suggested 19 times in the fingertip amputation case. Covering in the cases of CRPS and peripheral nerve injury was infrequent (2 and 4 times respectively). Following fingertip injuries covering to “protect” the finger, for scar management, and edema control is suggested in the text Rehabilitation of the Hand and Upper Extremity (Franzen & Katolik, 2021). Covering specifically to protect from pain / allodynia is not mentioned. In a previous version of this text covering an area to allow for function for individuals with CRPS was suggested if desensitization was unsuccessful. (Walsh, 2011) The reasons behind this seeming preference in our survey and the literature to cover for a fingertip amputation with allodynia but not for allodynia from other causes is unclear.

Cortical Representation Interventions. Participants recommended treatments targeting cortical representation (including promoting bilateral activities, imagined movement and sensation, mirror therapy, laterality recognition training, and GMI). While the exact mechanisms are not clear at the cortical level, central sensitization is thought to be an amplifier of peripheral input. (Devor, 2013) However, central sensitization may also become a pain generator without peripheral input in some individuals.(Woolf, 2018) The amount that each level contributes to allodynia is not fully understood; however, the predominant opinion is that peripheral processes contributing to sensitization in the spinal cord are the main driver of allodynia. (Devor, 2013) This opinion is challenged by the

work of Acerra (Acerra & Moseley, 2005) who demonstrated a phenomenon referred to as dysynchiria in 10 individuals with CRPS1. Dysynchiria is when watching the mirror image of the unaffected limb being stimulated elicits pain on the affected side, thus provoking allodynia solely through visual perception in the absence of peripheral input. Ushida (Ushida et al., 2005) demonstrated with fMRI that video observation of touch to a palm, or observation of a palm going to be touched (anticipation of touch), activated the brain differently compared to controls in 8 individuals with allodynia associated with CRPS or partial spinal cord injury. The individuals with allodynia showed increased activation in prefrontal and anterior cingulate cortex areas during the virtual tactile stimulation. Seven of the 8 individuals who completed the study (9 started and one dropped out due to "severe discomfort") reported "discomfort" or "irritation" during the virtual experience. These studies, with individuals with CRPS, of dysynchiria and virtual stimulation, suggest that allodynia may be provoked solely through visual perception in some individuals or that perhaps allodynia associated with CRPS may represent a unique mechanism or phenomenon.

There is evidence of altered cortical activation when an individual is experiencing allodynia. (Bailey et al., 2013; Geha et al., 2008; Peyron et al., 2004, 2013; Schweinhardt et al., 2006) Research on methods to alter cortical representation of a limb by Moseley (Moseley, 2004, 2006) and others (C. McCabe et al., 2003; Thieme et al., 2016) report decreased pain in individuals with CRPS and phantom limb pain, conditions which often present with allodynia.

However, the assessment of pain in these studies was via a NRS or VAS capturing resting / spontaneous pain – not evoked pain / allodynia. Thus, while GMI and its components appear helpful in the treatment of CRPS, the research in this area should be applied cautiously to allodynia on its own as studies have not assessed for changes in allodynia in response to GMI and its components. Applying touch to the unaffected limb during mirror therapy has been suggested (C. McCabe, 2011) and mirror therapy with a sensory focus was recommended in the survey. The treatment would be focussed at the cortical processing level and would not be painful to the participant. The high support for cortical representation treatments for allodynia (i.e., mirror therapy, GMI, imagined movement and sensations) shown in the survey suggests these approaches may be common in practice. To date there have been no studies that have specifically assessed the effect of cortical representation treatments on allodynia. This is an important avenue of potential research to determine if these treatments have an effect on allodynia in individuals with and without CRPS.

Psychosocial Interventions. Participants recommended psychosocial factors such as fear, anxiety, and ability to cope with pain be considered when treating allodynia, and treatment be modified accordingly. Strategies to reduce stress, obtain psychosocial support, and provide education were endorsed. This is congruent with a biopsychosocial approach to pain. Emotions are integral to the conceptualization, assessment, and treatment of chronic pain (Lumley et al., 2011) and cognitive-evaluative and motivational-affective inputs into the

individual's processing of pain are important. (Melzack, 2001) Evidence for the value of psychosocial interventions to reduce or manage pain is found in meta-analyses for individuals with rheumatoid arthritis, (Dixon et al., 2007) cancer, (Gorin et al., 2012) and chronic low back pain (Hoffman et al., 2007) The importance of treating the psychosocial aspects of pain is lacking in the allodynia literature but evident in our survey results, as presented in chapter 3, table 6 (page 69).

Delphi Technique - Lessons Learned

The use of the classical Delphi approach, with open ended questions in the first round had benefits and drawbacks. The primary benefit was that a substantive amount of comprehensive data were collected. Given the large number of suggestions, confidence was increased that areas important to the participants were adequately covered and that a method of assessment or treatment that is being utilized had not been missed. The primary drawback was that the data were not as focussed on allodynia as we had anticipated. Some participants provided assessments and treatments that focused on the impairment of allodynia, but the majority provided a wide range of assessments and treatments for the person with allodynia. As allodynia is rarely seen in isolation (Gierthmühlen et al., 2012) it is difficult to tease out one component of treatment from the many other concerns. The open-ended questions allowed for an extensive number of options being suggested and possible interrelationships between pain and other concerns added complexity to the study. For example,

there are interrelationships between pain and movement, (Karagiannopoulos et al., 2014; Rider, 2006) swelling, (Bosompra et al., 2002) sleep, (Finan et al., 2013) mood (Cochrane & Dale, 2019) and functional use. (Pelletier et al., 2020) As swelling and movement were frequently mentioned areas of assessment and treatment, we put them into the context of allodynia e.g., what treatments are recommended for edema when allodynia is present. While open ended questions were helpful to get the breadth of the topic and ensure important items were not missed, the scope of the information gathered had to be focussed back to allodynia through preamble instructions and wording of questions in subsequent rounds.

Given the large amount of data from the open-ended questions we had to design the round two survey to be a manageable length, yet not lose important information. Thus, while many of the suggestions appeared to be part of a comprehensive treatment plan for the clients depicted, and beyond a treatment for allodynia, it was necessary to treat all the suggestions equally as the Delphi process is based on the opinions of the group (Kennedy, 2004; Skulmoski et al., 2007). Initially we had considered a round two consisting of exploring the suggestions case by case with an *a priori* hypothesis that allodynia presenting with CRPS may have been approached differently than allodynia presenting post amputation or peripheral nerve repair. While there were some differences, they were not substantial enough to justify a case-by-case analysis. Also, given the multitude of suggestions we decided pooling the case data was necessary to

make round two less onerous for participants and to support engagement in the entire Delphi process. To help make up for this potential loss of information, in round two we asked several open-ended questions to try and capture why allodynia may be approached differently under different circumstances. More pilot testing of round one may have highlighted more clearly how participants would answer in response to the cases and perhaps questions could have been posed in a different way to better focus on allodynia.

Using a mixed methods approach added depth to our understanding of the topic. Delving into what participants thought about covering an area of allodynia is a good example of how the contextual details from qualitative information influenced our understanding and the development of questions in the subsequent rounds. For example, in round two we explored whether an area of allodynia should be covered or not. About one third of participants stated it should not be covered and two thirds stated it can be covered and the cover weaned. From these quantitative results, it would appear that there is a preference to cover the area. However, when the qualitative data were integrated into the analysis, most comments indicated a preference to not cover but gave reasons why a covering may be used. Thus, in round three we asked if participants recommend not covering but that in some cases it may be appropriate, which reached consensus. The use of the qualitative data allowed us to look deeper at the reasons behind recommendations and capture these specific details that would likely have been missed if only quantitative results had been used.

Exploring even deeper, we asked why participants preferred not to cover. From the previous comments we saw that some participants wanted the area touched while others didn't. About half preferred to not cover to allow the area of allodynia to contact objects in the environment / allow desensitization i.e., touch was considered desirable. The other half preferred not to cover as the cover would touch the area of allodynia i.e., touch from even a cover was considered not desirable. Thus, while the general recommendation to not cover an area of allodynia was agreed upon, it was due to quite different reasons. The integration of qualitative data allowed us to recognize and investigate these nuances.

How questions were posed influenced the response rate and information gathered. In round two a Likert scale was used with an option of "I have never used this" also given. In round three a yes / no method was used to gauge support for the items which had reached borderline consensus (defined as 60% to 74% agreement). While questions were not mandatory to answer and could be skipped, the response rate for many items was higher in round three. It is possible participants felt compelled to answer in round three when given a yes / no type of question and no option to indicate they had never used an item. The explorations around the Ten Test is the most striking example of this. In round two, 17 participants gave a Likert scale rating (13 of whom rated it 4 or 5 i.e., helpful) and 35 indicated they had never used it and thus The Ten Test met consensus, as consensus was based only on the 17 users. However, in round three when asking if it should be used on or near an area of allodynia in a non-

mandatory question with only yes/no options, 46 out of 47 participants gave an answer (18 choosing “yes” it is helpful on an area of allodynia thus not meeting consensus). It also did not meet consensus for use outside the area of allodynia. If the option of “I have never used this” was offered again in round three, the results may have been different.

Still related to how questions were posed, some interventions met consensus but on further questioning, how the technique was applied revealed a difference in opinion regarding whether the area of allodynia be included or not. Based on participant feedback, in the fourth round “sometimes touching and sometimes avoiding” was given as an option for several questions and was selected often. For example, soft tissue work / mobilization / scar massage as well as manual edema techniques both met consensus but opinion on how they should be applied varied. In both cases the majority suggested it depended on clinical reasoning considering the client presentation. If this “it depends” option was given in earlier survey results may have been different.

We made rules for each round and followed them with few exceptions (previously described). It is clear that breaking a rule can have notable consequences on the outcome of the study. For example, in round one few assessments for cortical representation were suggested, but many treatments were. We made an exception to the rule for dropping items suggested less than four times and included these cortical representation assessments in round two for voting on. We did this as we were interested in whether these areas were

being assessed for, given the many related treatments put forth. Consequently, despite being suggested infrequently in round one most cortical representation assessments reached consensus in later rounds and are included in the recommendations.

Delphi studies offer a snapshot of expert opinion, for that group, at the time it was collected. (Hasson & Keeney, 2011). It is important to recognize that our survey results are opinion-based and thus are considered a low level of evidence. (Howick et al., 2011) Also, many of the recommended assessments and treatments have limited or no research to support them at this time. As knowledge improves, opinions may change, and recommendations would need to be updated. We invited participants from 21 countries with an effort to include approximately equal numbers of participants from three regions i.e., Europe, North America, and countries outside of Europe and North America. However, we lost more participants from countries outside of Europe and North America, so opinions are likely less representative of global opinion than we had hoped and are more representative of opinion of therapists practicing in Europe (with 19 contributing to round four) and North America (with 14 contributing to round four) vs only 10 from other countries.

As disagreement on whether an area of allodynia should be touched or not was a common point of dissent, it is possible a different version of the Delphi technique could have looked at this particular issue in a more applicable way. Emerging dissensus-based Delphi methods (Rowe & Wright, 2011; von der

Gracht, 2012) are designed to stimulate structured conflicts with the goal of comparing opposing views. As our study methodology focussed on consensus it may not have been as effective to elucidate some of the disagreements found.

Multiple rounds with good retention of participants supports content validity. Despite four rounds and retaining 43 out of 54 participants, we noted some assessment items that are in the literature, i.e., assessment of dynamic mechanical allodynia and of cold sensitivity, did not make it into the final results. These items were included at the beginning but dropped due to low support. It is unclear why these areas were not supported. It is suggested that even with a well-planned Delphi, results may not be exhaustive or all inclusive. (Clayton, 1997) Use of the snowball technique in recruitment brought in some less experienced therapists. While this helped to broaden the input, it is possibly a threat to expertise and the construct validity since the goal of the study was to collect expert opinion.

Some limitations were related to language. These included, the survey was limited to English speaking therapists, not all assessments are translated to / from English, SRM has been taught mainly in French and thus is not as accessible to English speaking therapists, and language / terminology used may not be representative for all therapists due to cultural differences e.g., use of ‘client’ vs. ‘patient’, and the use of terminology (e.g., desensitization) is not always consistent.

Summary of recommendations

This thesis adds to the rehabilitation science and hand therapy literature by providing expert recommendations for management of allodynia of the hand and introducing a new definition of hypersensitivity. The limited literature review presented in in chapter 1 suggests there is a paucity of rehabilitation research related to the assessment and treatment of allodynia. Most of the research has evaluated various approaches to tactile stimulation as a treatment for allodynia. More work is needed in this area to help understand how best to assess for and treat allodynia. This work also adds to the Delphi method literature in highlighting the importance of specifying the level of the target recommendations, particularly in health professionals who may use a holistic framework. The inconsistency of responses seen focused on the impairment compared to focusing on overall management of the person illustrate the need for such specificity. The following summary of recommendations has been generated through consideration of both the literature review (individual studies, guidelines, textbooks) and survey results.

Key Recommendations for Research

1. Agreement on the meaning of the term “desensitization” is needed. Clearly indicating the location of the stimulation in relation to the allodynia, the purpose of the technique and the target of the intervention is recommended. The proposed definition by Packham (Packham, 2021) meets all these criteria. Having this definition reviewed, and modified if needed, through a consensus process is recommended.

2. Currently touching near an area of allodynia is also referred to as "desensitization". A different term should be sought for this approach to reduce confusion and allow easier comparison within future research.
3. Future intervention studies would benefit from thorough assessment of the allodynia:
    - Assess both static and dynamic mechanical allodynia (using the rainbow pain scale for static and quantitative sensory testing for dynamic).
    - Assess the size and location of the allodynic area using a standardized approach, such as allodynography or a grid marked on the skin, to monitor shrinkage and shifting of location, to determine what cutaneous nerve branch(es) are likely involved, and if the allodynia appears to be localized or widespread.
4. To help capture the impact of the allodynia:
    - Use of a validated assessment of upper extremity function with standardized items, and a validated assessment of client-identified important items.
    - Use of the McGill Pain Questionnaire (full length or short form) / Questionnaire Douleur St. Antoine (Boureau et al., 1992; Dworkin et al., 2009; Melzack, 1975)
5. To help predict response to treatment:

- Use of the Pain Catastrophizing Scale (Sullivan et al., 1995) and an assessment for anxiety.
- Use of the assessment Douleur Neuropathique 4 (Bouhassira et al., 2005) to help determine if pain is neuropathic vs. nociceptive.
- Use of the Central Sensitization Inventory. (Mayer et al., 2012)
- Grade the severity of the allodynia using the rainbow pain scale to differentiate degrees of allodynia.

6. To improve the ability to replicate and compare future research:
    - If painful tactile stimulation is used, clear guidelines around what amount of pain increase is acceptable during the study via a numeric rating scale or visual analogue scale. Define the term “tolerable” if it is used for clear stopping rules.
    - If the approach of moving from outside the area of allodynia into the painful area is used, clearly stating when and why this transition was made.
7. Tactile stimulation approaches and underlying theories need to be tested. Comparing a program of desensitization (touching directly on an area of allodynia) to a program of Somatosensory Rehabilitation of Pain Method in individuals without complex regional pain syndrome is a recommended first step.
8. Evaluating if interventions that may improve the environment in which nerves function has an impact on allodynia (edema reduction, increased

range of motion, mobilization of tissues and, mobilization of the nervous system itself).

9. Determine if cortical representation of a limb is altered in individuals with allodynia who do not have a diagnosis of complex regional pain syndrome.
10. Evaluate if approaches to altering cortical representation have an effect on allodynia in individuals with and without complex regional pain syndrome.
11. Qualitative research to gather clients' perspectives and experiences with different approaches to treatment may identify important perspectives, including indications and contraindications.
12. If studies find certain approaches effective, then establishing the ideal dosage and duration would be necessary to support implementation into clinical practice.

Key Recommendations for Clinicians

1. A comprehensive individualized assessment and treatment plan for allodynia is recommended using a biopsychosocial perspective. Consider underlying mechanisms, functional status, and psychosocial status (level of anxiety, coping skills, perspective re pain, and overall stress systems activity) when selecting assessment and treatment approaches.
2. Assess for static mechanical allodynia, noting the location and size of the area and quantify the intensity of the allodynia. If trained in Somatosensory

Rehabilitation of Pain Method use the tools of allodynography and the rainbow pain scale.

3. Consider assessing for peripheral influences on the nervous system that may contribute to allodynia such as neural tension, compression, and soft tissue quality / scar condition.
4. An area of allodynia should probably not be covered with a splint / gel / glove etc. except in certain circumstances which are: if it helps improve function, for specific tasks only, or if needed for other medical concerns (such as edema or contracture management). If a cover is used it should be as comfortable as possible.
5. Therapists and clients should probably avoid touching an area of allodynia in individuals with complex regional pain syndrome.
6. Desensitization (touching on the area of concern) was first described for “hypersensitive” hands and has been used for dysesthesia as well as allodynia. Evidence for this approach is limited and study quality is considered low to very low. (Quintal et al., 2021) This approach may be more appropriate for smaller areas of dysesthesia, but more research is needed.
7. SRM is a relatively newer approach which avoids touch on an area of allodynia and uses distant counterstimulation. Limited research suggests a strong effect size on pain outcomes (Packham, Spicher, et al., 2018) but more research is needed, and training is required to employ this approach.

8. Approaches to altering cortical representation of a limb may help with complex regional pain syndrome but the effectiveness of these approaches in altering allodynia is unknown, and this should be a consideration when evaluating treatment response.

Key Recommendations for Education

1. Increase access to learning the Somatosensory Rehabilitation of Pain Method. For example, an updated English handbook and online training would increase accessibility of this method.
2. Students and therapists should be informed of the various approaches to tactile stimulation, as well as cortical representation approaches, including the underlying theories, and evidence (or lack thereof) for each.

Knowledge translation

The newly created definition of hypersensitivity, and the assessment and treatment options generated through this work are important to share with students in the rehabilitation professions and fellow therapists. The new definition may help to reduce confusion around what the term “hypersensitivity” means in hand therapy and can be a point of discussion to contrast and compare with already established related International Association for the Study of Pain definitions. The lists of assessment and treatment options may help to improve care for persons with allodynia affecting their hands. To accomplish the dissemination of this information a journal article is planned to summarize the study and its findings. A presentation has already been done at the American

Society of Hand Therapists annual conference on whether an area of allodynia should be covered or not and an abstract has been submitted to the International Federation for the Society of Hand Therapists conference on what "desensitization" means.

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Appendix A: Round One Vignettes

Case One

A 57-year-old female executive is 10 weeks post distal radial fracture with a diagnosis of complex regional pain syndrome. She presents with typical post casting stiffness and moderate diffuse swelling and sweating of the affected hand. She is quite anxious and reports high levels of pain, poor sleep and decreased social interaction. She is unable to tolerate touch in her palm or the dorsum of her wrist and thumb. She cannot tolerate clothing touching her dorsal radial wrist and is using her hand very little.

Case Two

A 27-year-old male laborer is seen 6 weeks post tip amputation of his right dominant middle finger. He reports his whole finger is sensitive to touch. His range of motion is good and he is using his hand for activities of daily living, most tasks at home and light duties at work. However, his finger is painful enough that he tends to keep it in extension during hand function.

Case Three

A 52-year-old male window installer is seen at 4 weeks post repair (partial 80%) ulnar nerve laceration at the wrist after being cut by a shard of broken glass at work. There is no tendon injury. He presents with diffuse mild to moderate swelling and typical ulnar nerve motor and sensory loss. He reports constant numbness and pain in response to static and moving touch as well as cool temperatures in the ulnar nerve distribution of his hand. The pain is distressing

and is affecting his sleep. He is considering sleeping in the guest room to avoid contact with his partner at night. He is trying to use his hand but avoids letting anything touch the ulnar side. He has been wearing a bowling splint most of the time to reduce contact with the painful area.

Appendix B: Assessment and Treatment Items Suggested at Least Three Times in Round One

Table 1

Assessment Categories and Number of Times Items Were Suggested per Category

Assessment category Round One	**Number of times items suggested**
Pain intensity	175
Sensory assessments (details in table 2)	133
Physical	132
Pain questionnaire	119
Pain location	83
Functional use	29
Psychosocial function	30
Cortical representation	21

Table 2

Specific Items Suggested in the Category of Sensory Assessment

Sensory assessments	**Count**
Use of monofilaments	40
Response to non nociceptive stimuli; light touch / tapping / stroking / brush / pressure / materials / textures / dowels	20
2-point discrimination (static or dynamic)	19
"Sensory testing" or "assess for allodynia"	13
Temperature sensation / cold intolerance	9
Response to nociceptive stimuli	5
Ten Test	4
Other (all mentioned 3 or less times)	23
Total	**133**

Table 3

Treatment Categories and Number of Times Items Were Suggested per Category

Treatment category Round One	**Number of times items suggested**
Sensory interventions (details in table 4)	202
Education	125
Cortical representation	115
Modalities (TENS)	91 (23)
Active exercise	83
Splints / protection	76
Functional use / activity	65
Psychosocial / support	65
Edema management / circulation	65
Hands-on interventions	31

Table 4

Specific Items Suggested in the Category of Sensory Interventions

Sensory interventions	**Count**
"Desensitization" (2 stated directly on, 11 stated near, 66 location was not specified)	79
Somatosensory Rehabilitation Method techniques	49
fluidotherapy / sensory bombardment / immersion / exposure to stimuli / touch / pressure / tapping / massage	47
sensory reeducation / retraining (stereognosis, localization, 2-point discrimination)	19
vibration	4
Other (all mentioned 3 or less times)	4
Total	**202**

Appendix C: Items Dropped Over the Rounds

Table 1

Assessment Items Dropped Over the Rounds

	Results after round:		
	two	**three**	**four**
ASSESSMENT items dropped	Number of participants who provided an opinion, % agreement item is helpful		
Interview questions			
Pain related questions			
Is there difficulty with exposure to heat?	n = 52, 69%	n = 47, 70%	n = 43, 63%
Is there difficulty with exposure to vibration?	n = 52, 67%	n = 47, 68%	
Questionnaires			
Pain questionnaires			
Brief Pain Inventory	n = 22, 73%	n = 46, 61%	n = 36, 56%
Cold Intolerance Symptom Severity	n = 17, 65%	n = 47, 40%	
PROMIS pain related domains	n = 11, 64%	n = 46, 41%	
Neuropathic Pain Symptom Inventory	n = 12, 58%		
Radboud Evaluation of Sensitivity	n = 7, 43%		
Function questionnaires			
Upper Extremity Functional Index	n = 12, 67%	n = 44, 39%	
Quick Disabilities of the Arm, Shoulder and Hand	n = 47, 62%	n = 46, 61%	
Canadian Occupational Performance Measure	n = 34, 62%	n = 46, 43%	
Disabilities of the Arm, Shoulder and Hand	n = 43, 56%		
Short Form 36	n = 29, 31%		
'Top down' questionnaires			

Hospital Anxiety and Depression Scale	n = 15, 73%	n = 46, 41%	
PROMIS profile	n = 11, 64%	n = 44, 48%	
Tampa Scale for Kinesiophobia	n = 19, 58%		
Bath Body Perception Disturbance scale	n = 6, 50%		
Assessment approach			
Consider conducting assessments that may increase pain towards the end of the session		n = 47, 53%	
Assessment of pain intensity			
Use NRS or VAS to assess pain at night	n = 52, 54%		
Use NRS or VAS to assess pain during AROM	n = 52, 52%		
Use NRS or VAS to assess pain with touch in general	n = 52, 50%		
Use NRS or VAS to assess pain rated for specific materials	n = 52, 25%		
Use NRS or VAS to assess pain during PROM	n = 52, 19%		
Pressure pain threshold assessment	n = 52, 56%		
Assessment of pain location			
Clinician drawn based on client's description	n = 39, 74%	n = 47, 68%	n = 42, 69%
Clinician drawn using monofilaments (other method)	n = 33, 64%	n = 46, 33%	
Clinician drawn using textures and VAS	n = 21, 38%		
Assessment for a central component			
Ability to imagine sensation and which, if any, increase pain	n = 29, 71%	n = 46, 70%	n = 43, 74%
Client to draw both upper extremities	n = 16, 69%	n = 46, 57%	
Laterality – other method	n = 15, 67%	n = 46, 15%	
Sensory assessment			

Response to materials, textures, dowels	n = 43, 65%	n = 47, 57%	
cold intolerance -assessed via cold water in a test tube or alcohol swab	n = 36, 64%	n = 47, 45%	
Response to tapping, stroking, pressure	n = 40, 63%	n = 46, 50%	
Response to light vs. firm pressure	n = 40, 60%	n = 47, 49%	
Response to vibration	n = 37, 59%		
Response to nociceptive stimulation	n = 34, 56%		
Two point discrimination	n = 47, 53%		
Hot / cold sensation	n = 43, 42%		
Monofilaments for detection of light touch -adjacent to the area -on the area		n = 47, 57% n = 45, 29%	
Physical assessment			
Nerve compression	n = 45, 73%	n = 47, 68%	n = 41, 51%
Grip / pinch strength	n = 48, 71%	n = 47, 53%	
Edema (visual, circumferential or volume)	n = 50, 66%	n = 47, 66%	
Neural tension	n = 45, 64%	n = 46, 54%	
Proprioception	n = 44, 64%	n = 47, 60%	
PROM of affected and unaffected joints	n = 52 52%		
Dexterity	n = 42, 50%		
Manual muscle testing	n = 48, 48%		
Visual estimate of functional ROM	n = 52 38%		
AROM of unaffected joints	n = 52 17%		
PROM of unaffected joints	n = 52 13%		

Key: NRS= numeric rating scale, VAS= visual analogue scale, PROM= passive range of motion, AROM= active range of motion, ROM= range of motion.

Table 2

Treatment Items Dropped Over the Rounds

	Results after round:		
	two	**three**	**four**
TREATMENT items dropped	Number of participants who provided an opinion, % agreement item is helpful		
Sensory intervention			
vibration	n = 41, 49%		
Sensory bombardment / immersion / flooding / exposure	n = 39, 33%		
Fluidotherapy / whirlpool	n = 30, 37%		
Graded pressure via putty, tapping, massage -outside the area -within the area	n = 41, 66%	 n = 45, 58% n = 46, 39%	
Sensory reeducation - stereognosis, localization, discrimination within the area of allodynia		n = 47, 49%	
If the allodynia is felt to be more due to peripheral drivers direct desensitization on the area		n = 46, 61%	n = 41, 66%
Other physical intervention			
Approaches to improving movement (with allodynia in the presence of reduced movement)			
Strengthening	n = 49, 24%		
Edema management (with allodynia in the presence of edema)			
Diaphragmatic breathing	n = 32, 72%	n = 46, 52%	
Core exercises	n = 28, 54%		
Whirlpool	n = 25, 32%		
Fluidotherapy	n = 22, 32%		
Modalities			
Warmth / moist heat -including the area -avoiding the area	n = 38, 61%	 n = 45, 44% n = 46, 33%	
Fluidotherapy with heat	n = 24, 46%		

without heat	n = 20, 45%		
Whirlpool with heat without heat	n = 21, 29% n = 14, 36%		
Muscle stimulation	n = 19, 37%		
Ultrasound in or out of water	n = 23, 26%		
Contrast baths	n = 37, 22%		
Manual techniques			
Massage for relaxation / promoting circulation -Including the area -avoiding the area -regardless of whether area is touched	n = 38, 71%	n = 47, 40% n = 46, 61%	n = 42, 69%
Neurodynamic exercises (assuming evocative elements are avoided)	n = 40, 63%	n = 47, 64%	
Neurovascular / myofascial release	n = 29, 45%		
PROM unaffected joints	n = 40, 43%		
PROM affected joints	n = 47, 38%		
'Top down' intervention			
Functional intervention / other			
Buddy taping to promote function	n = 43, 74%	n = 47, 38%	
Splinting at night	n = 50, 56%		
Use of kinesiotape	n = 40, 53%		
Techniques to alter cortical representation			
Mirror therapy – just looking, no movement or sensory stimulation	n = 44, 66%	n = 46, 48%	
Education			
Avoid stimuli that increase pain	n = 52, 56%		

Key: PROM= passive range of motion.