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The journal publishes original clinical and basic science articles; reviews on pertinent topics not recently covered by other international journals; clinical and experimental notes, such as case reports of educational or scientific value, qualified and long-term clinical observations, technical advances in clinical practice and experimental research, therapeutic studies or experiments with negative results and pain-provoking procedures; short communications on clinical or basic science articles; and letters to the Editor.

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Contents

Editorials
Fernando Cervero 297

A tribute to Professor Ulf Lindblom, MD, PhD
Per Hansson 299

Guest Editorials
Ulf Lindblom, friend and mentor
Aleksandar Beric 301

Ulf Lindblom – a very distinguished neurologist
J.-M. Besson 303

Ulf Lindblom: a personal memoir
David Bowsher 305

Thank you, Professor Ulf Lindblom
Harald Breivik 307

Ulf Lindblom, the first steps
Jan-Otto Ottersson 309

Research Papers
Pain questionnaires in the analysis of long lasting (chronic) pain conditions
Anders Wincent, Ylva Lidén and Staffan Amér 311

Master scaling of perceived intensity of touch, cold and warmth
Birgitta Berglund and Eva-Liz Harju 323

Spinal cord injury pain
Aleksandar Beric 335
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central pain and the role of quantitative sensory testing (QST) in research and diagnosis</td>
<td>339</td>
</tr>
<tr>
<td>Jögen Boivie</td>
<td></td>
</tr>
<tr>
<td>Secondary hyperalgesia and presynaptic inhibition: an update</td>
<td>345</td>
</tr>
<tr>
<td>Fernando Cervero, Jennifer M.A. Laird and Esther Garcia-Nicas</td>
<td></td>
</tr>
<tr>
<td>Difficulties in stratifying neuropathic pain by mechanisms</td>
<td>353</td>
</tr>
<tr>
<td>Per Hansson</td>
<td></td>
</tr>
<tr>
<td>The Lindblom roller</td>
<td>359</td>
</tr>
<tr>
<td>Paolo Marchettini, Claudio Marangoni, Marco Lacrenza and Fabio Formaglio</td>
<td></td>
</tr>
<tr>
<td>Ulf Lindblom and spinal cord stimulation</td>
<td>365</td>
</tr>
<tr>
<td>Björn A. Meyerson</td>
<td></td>
</tr>
<tr>
<td>Quantifying sensation: “Look Back in Allodynia”</td>
<td>369</td>
</tr>
<tr>
<td>José L. Ochoa</td>
<td></td>
</tr>
<tr>
<td>How Ulf Lindblom changed my life: studies of the mechanisms of pain and abnormal sensations following nerve injury and their treatment in cats, rats and humans</td>
<td>375</td>
</tr>
<tr>
<td>Zsuzsanna Wiesenfeld-Hallin</td>
<td></td>
</tr>
</tbody>
</table>

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This is a very special issue of the European Journal of Pain dedicated to celebrate Ulf Lindblom’s contributions to pain research both as a scientist and as a clinician. It is not a hagiographic celebration of Ulf’s greatness – though it could have easily been so, as Ulf’s achievements are many – but, more to Ulf’s liking, we have produced an issue that offers the reader an insight into his work through a collection of research papers addressing timely topics on the science and management of pain. We are looking to the future not to the past, a future that is only possible because of the accumulated work of exceptional people. And Ulf Lindblom is one of these exceptional people.

Ulf is the founding Editor-in-Chief of this journal and the driving force behind its creation. He wanted to have a first class scientific journal dedicated to pain research and management under the auspices of EFIC (the European Federation of Chapters of IASP) and fought long and hard to achieve this goal. The best tribute to Ulf’s hard work and determination is this very journal, a publication that in a short space of time has achieved a high reputation for quality and fairness and has provided EFIC with a very respectable publishing venture. We owe the success of this journal to his vision and to his hard work.

This issue will appear at the time of EFIC’s 4th Congress in Prague, an event that shows the coming of age of EFIC as a European forum for pain research and management. Ulf Lindblom will receive an honorary membership of EFIC at the Congress as well as the gratitude and recognition of his friends and colleagues. The European Journal of Pain joins in this happy event with the production of this special issue, in the knowledge that he will be pleased to see his journal flourishing. Ulf was President of IASP and of EFIC but we know that in addition to his service to these organizations he specially valued his work for the European Journal of Pain.

I am personally very grateful to Per Hansson, a member of our Editorial Board and long time friend of Ulf, for his hard work as Guest Editor of this issue. Per Hansson has achieved the difficult tasks of organizing an impressive issue of the journal and of getting busy and important scientists and clinicians to deliver their manuscripts on time. I am also grateful to the authors, not only for their timeliness, but for their excellent scientific contributions to this issue of the journal. And I am extremely grateful to Ulf for having asked me to join this venture from the beginning as his Deputy-Editor and for having helped and encouraged me to continue his work with the journal. Following in Ulf’s footsteps is no mean feat and I hope that he will be pleased to see that his journal is going from strength to strength.

Fernando Cervero
Editor-in-Chief
Editorial

A tribute to Professor Ulf Lindblom, MD, PhD

This supplement, a collaborative effort of friends and scientific as well as clinical colleagues, is a tribute to Ulf Lindblom as the founder of the European Federation of IASP Chapters, and the European Journal of Pain (EJP), founding member of the International Association for the Study of Pain (IASP) and for his scientific and clinical contributions within the area of neuropathic pain. The endeavour of putting the volume together was agreed on at the Editorial Board meeting of the EJP during the IASP World Congress in San Diego in 2002.

The contents of this issue and the contributors to it were decided through interactions between myself and the Editor in Chief and the Deputy-Editor. All who were approached agreed to contribute even though they are busy and overcommitted individuals in their respective fields.

I would like to extend my sincere thanks to all who have collaborated in making this issue possible.

Ulf, thank you for sharing!

As a clinical and scientific colleague, Ulf is best characterised as generous, considerate, unselfish, and analytical and has the typical delayed reaction pattern of many neurologists to any suggestion or provocation. He is also demanding in a subtle way, contaminating people in his immediate presence with matters that suddenly seem of crucial importance to them. I have fond memories of such events, usually triggered by remarks that unmask limitations of your own knowledge, urging you to seek information.

Many colleges have witnessed his superior abilities as a clinical neurologist, from taking a meticulous history to a contracted and logical examination as a basis for a careful combined diagnostic analysis of symptoms and signs. His insights, sometimes intuitive, into the function of the nervous system are immense and cannot be overestimated. Intriguing discussions trying to bridge the gap between clinical symptoms and signs of pain and the possible underlying neurobiological events have since long flavored scientific and clinical round table sessions with Ulf as a participant. Having had the opportunity to work with Ulf both clinically and scientifically I can only feel sorry for those who have been less fortunate. A more knowledgeable source of inspiration within the field of neurology and neuropathic pain is hard to come by.

Per Hansson
Karolinska Hospital Institute
Stockholm, Sweden
Ulf Lindblom left an unforgettable impression on my professional career and, more importantly, on my personal life. I’m so grateful to Ulf that this may sound like the story of my life and not about Ulf. But that’s the whole point of great people. They influence other people, change their lives, make them feel worthy of their effort and just fuller and happier as clinicians, researchers, and just ordinary folks.

Our interaction began about 20 years ago as part of a developing collaborative effort between a Houston-based spinal cord research team led by Milan Dimitrijevic and a Stockholm-based pain research team led by Ulf Lindblom. With my evoked potential and sensory physiology background I became a trainee for spinal cord pain research under Ulf’s guidance and spent an incredible 2 months in Stockholm. My wife, Bojana, (who was expecting our son, Teodor) and I had recently left Yugoslavia, and both of us were at the crossroads of our medical careers. This was what could be called “trying times”. Ulf, with his focused systematic crescendo sharing of his pain research ideas, and his wife, Berit, with her motherly warmth and painless teaching of quantitative sensory techniques, made Bojana and I part of their lives and part of the Karolinska family. That winter we not only saw, but also felt Stockholm’s Santa Lucia’s lights. They made sure we spoke with Nobel laureates, danced with Swedish royalty and at the same time prepared fundamentals of the study of pain in spinal cord injury, a study that continued for the next 6 years. We felt that Berit and Ulf were ours and our unborn son’s godmother and godfather who showed you the stars, but were modest at the same time, both in life and in work. That December, for the Nobel Dinner, I wore Ulf’s father’s tails. I was thrilled at the time about the whole event, but only as I mature, (read: grow old), I understand what Ulf really did for me. He has always been a careful researcher and clinician, knowing the basics of human physiology and everything about sensory techniques and assessments. Ulf never speculated for the sake of speculation, never forgot that patients were there for a reason, and that reason was to be helped and freed from pain. We shared a common personal trait in being detailed-oriented, liking databases and all-inclusive things, and we liked being “splitters”, not “lumpers”; everything counts and has a reason for being.

As the Houston project was completed and we moved to New York, my interest shifted towards Parkinson’s disease. Despite the end of our spinal cord pain research, we continued with direct contacts, which became less and less as Berit gradually reduced her travels. Family life, my wife’s teaching career and my clinical responsibilities reduced our travel to a minimum, making contacts with Ulf scarce.

After my almost 30 years of practice and academics I grew to understand there were a number of people that either mentored, offered the opportunity to grow or were just there when you needed them. I feel that Ulf was all of these for me. This is not an exaggeration, as there are only a couple of other friends that fall into this category, the category of people that you one day tell your grandchild about while sitting in your lap. Tine Prevec from Ljubljana is one of those, the man who taught me all I know about neurophysiology and everything else, and Keith Light, who taught me neurology and was there just when it counted. I wish I could figure out how to let these good people know what they have done for me and my family. Life is too complicated and New Yorkers make you forget about the rest of the world. Writing this letter is an opportunity to reflect; what you did and did not.

Now I teach people about pain, sensory assessment, allodynia and hyperalgesias, and keep Ulf’s presence in my lab. I teach evoked potentials and keep Tine’s presence and uro-neurology, and keep Keith’s presence around. Is that enough? I always thought providing knowledge, friendship and opportunities to young colleagues are tributes to my great mentors and teachers. Maybe this is not enough. Maybe a short visit or a letter like this is a must. You be the judge!

Aleksandar Beric  
NYU School of Medicine  
New York, NY, USA
Guest Editorial

Ulf Lindblom – a very distinguished neurologist

I first got to know Ulf Lindblom towards the end of the 1960s, through his scientific publications, notably on the subject of the spinal cord and in particular, his studies with JO Ottoson that provided evidence for a supraspinal control exerted on sensory transmission at the level of the first synapses in the dorsal horn.

We then became part of the very first Council of the International Association for the Study of Pain (IASP) from 1975 to 1986. During many meetings, I came to appreciate from a general point of view, the numerous comments and suggestions from Ulf Lindblom that were always full of good sense, pertinent and assured the progress of the Association.

Something that struck me at this time was his desire and commitment, always clearly expressed, to develop the scientific quality of the IASP. For 25 years I was impressed by the total commitment of Ulf in the field of research on pain. He is quite clearly a neurologist with an encyclopedic knowledge of the literature. Furthermore, he has not ceased to follow and encourage the development of scientific research that links the fundamental to the issues that arise in the clinic. Indeed he has stimulated, guided and suggested very many clinical studies of the highest quality. Being alongside Ulf at many meetings, I have been impressed by his ability to look into the future, his meticulous attitude and his critical spirit. His interventions so clearly revealed his human qualities and without doubt brought help and assistance to patients suffering from chronic pains.

On the topic of the scientific aspects of the career of Ulf Lindblom it is obvious that his publications (around 150), reflect his dual background in Neurophysiology and Clinical Neurology. He quickly became interested in the development of different psychophysical techniques in healthy individuals and also in patients with various presenting symptoms of neurological conditions associated with pain. The most remarkable aspect of his research that dominates the literature is that on “Quantitative sensory testing” or QST. These techniques have allowed a much more systematic and rational approach to the study of patients with profiles of pain-related sensory abnormalities characteristic of peripheral neuralgia. These works provided a basis for the classification of different types of neuropathies based in particular on the abnormalities of hyperalgesia and allodynia. The techniques of Ulf Lindblom have been very widely used throughout the world and today are used to allow a much better diagnosis but also a much better evaluation of the potential therapeutic effects of a number of different substances. There is no doubt at all that the techniques that Ulf introduced have a bright future since each year the list of publications on the subject of allodynia and hyperalgesia in animals increases dramatically but the last word rests with the clinical research. This point is well illustrated by the fact that in the field of neuropathies a considerable number of compounds are active in animals but clinicians are still confronted by difficulties in treating pains since they are often dealing with multiple syndromes. It can be clearly stated that QST forms a basic reference to study, in man, various pathophysiological and pharmacological aspects of different mechanisms that contribute to pain states.

Ulf Lindblom rose with success to be the President of IASP from 1990 to 1993 where again his rigor and his charm that assured that the high standards of our Association were widely appreciated. Put in charge of the Local Organizing Committee for the Congress in Paris in 1993, I recall a fruitful collaboration with Ulf where he never failed to encourage us and share his advice and wisdom.

Ulf Lindblom has always been convinced by the merits of improving relations and collaborations between different European groups. His experience acquired at IASP lead to the suggestion that EFIC be formed and he became President from 1992 to 1995. He quickly established the European Journal of Pain which has acquired a fine reputation. I can affirm that the endeavors of Ulf Lindblom have never been for personal ambitions and gains but rather it has been the battle against pain that has been his motivation. He has been faced with problems over a number of years in bringing forward his projects but has, yet again, stood with courage in maintaining the highest possible standards in the functions of EFIC. I can assure him that we owe him a lot.

From a personal point of view, I wish to finish in assuring Ulf of my greatest affection for him and I wish...
to thank him warmly for all he has brought for us in a number of different areas. I am sure that the whole pain community will join with me in expressing to Ulf our recognition of his talents and our gratitude to be able to pay homage to this “bright Neurologist”, a clinical researcher with a great talent.
I visited Sweden several times in the very early 1970s, mainly to work in Uppsala. While there, I was invited on more than one occasion to lecture in Stockholm—largely by neurosurgeons, because of my interest in pain and cordotomy. On one of these occasions, I was introduced to Ulf, who invited me to come and see his laboratory.

My visit was like a first glimpse of paradise. While I had vaguely wondered about quantitative sensory threshold tests other than von Frey filaments, here it all was. I remember the scene distinctly: Ulf sitting on a stool, surrounded by various pieces of equipment, Berit sitting on a high chair and organising the testing sequence.

In the course of the day, I underwent a demystification process and learned about (and was subjected to) the testing procedure. It was all made easier by Ulf’s patient and kindly explanations and Berit’s sharp warmth. As soon as I got home, I arranged for my then Research Registrar (Juan Lahuerta) to spend some time with Ulf and thoroughly to learn the procedures and their interpretation. When he came home, our then Physicist/Physiologist, Jackie Campbell, built a thermal threshold testing apparatus according to the designs and circuits kindly supplied by Ulf and his team. We started doing QSTs in Liverpool in the middle 1970s, and successfully used our home-made equipment until a commercial model became available from Sweden.

Jackie Campbell and I went to Stockholm to visit Ulf professionally some time in the later 1970s. We were going on to visit another lab, so Ulf very kindly lent us a car. When it broke down on the outskirts of Stockholm we rang Ulf from the garage to which we’d had it towed, whereupon he drove out, took us home, and lent us another car!

During a meeting in Venice of the Presidents and Hon. Secretaries of the European IASP Chapters (a predecessor of EFIC), Ulf and Berit and I managed to visit and enjoy a large number of the city’s artistic treasures, and to attend a performance of Donizetti’s “Maria Stuarda” at La Fenice before it was burnt down.

When we arrived in Adelaide for the IASP World Congress, my wife was suffering from acute ophthalmic shingles. As soon as I told Ulf, he dashed up to examine her sensory state (those of us who were studying PHN hardly ever saw acute herpes zoster). Despite its investigative nature, my wife got the impression that being examined by him made her feel better. This was more than she could say for several of the other IASP members who manhandled her left V1 area at the time!

Ulf and Berit excelled themselves in hosting a Wenner-Gren Symposium in Stockholm. It was perhaps easier to see there why they are so universally popular all over the world. Every time we go to an international meeting, my wife and I look forward to the warmth of a meeting with them. They remember everyone’s name, they make friendly conversation with all who come by, and make everyone feel welcome. It is of course possible (and interesting) to have profound and helpful scientific discussions with Ulf. Even when he disagrees deeply with someone else’s hypotheses, he never indulges in unkind remarks about the author or suggests that the propounder is stupid.

Other contributors will have written about the importance of Ulf’s scientific achievements. This is about Ulf and Berit as people, whose humanity is evidenced by their relations with their large and close-knit family and their myriad friends. I just hope to help readers understand why Ulf and Berit are, rightly, among the most widely cultured, popular, and well loved people in the world of neurology and pain studies—and, incidentally, my wife says Ulf is the best dancer she’s ever been on the floor with! So we expect to discover new and previously unknown talents (juggling; trapeze acts) in Ulf every time we meet him.

This is the Ulf (and Berit) I have known for 30 years and more. I hope others will appreciate what a privilege it is to know them both professionally and socially, and that we shall all continue to enjoy their advice, their company, and their conversation for many more years to come.

David Bowsher
Pain Research Institute
University Hospital Aintree
Liverpool, UK
Guest Editorial

Thank you, Professor Ulf Lindblom

Ulf Lindblom made the ideals and purpose of the International Association for the Study of Pain (IASP) come true in Europe: “To foster and encourage research of pain mechanisms and pain syndromes and to help improve the management of patients with acute and chronic pain by bringing together basic scientists, physicians, and other health professionals of various disciplines and backgrounds…”

Ulf Lindblom founded EFIC, the European Federation of Chapters of IASP. He was elected the first President of EFIC. He created the European Journal of Pain, the official scientific journal of EFIC. He is the first and only honorary member of EFIC. Ulf Lindblom is a founding member, past President, and honorary member of IASP.

I first met Ulf in Stockholm in December 1976 when he, Björn Meyerson and Staffan Arnér, the “Karolinska Pain-Troika”, had invited a handful of IASP members to Stockholm to form the Scandinavian Association for the Study of Pain (SASP), the first regional chapter of IASP. Under the able and always friendly and stimulating leadership of Ulf Lindblom the Scandinavian Association for the Study of Pain rapidly developed into a very active scientific pain society, which illustrated very clearly the strong synergistic effects of applying the IASP principle of multidisciplinary collaboration between health professionals and basic scientists interested in the study and management of pain. Together, the five small Nordic countries have clinicians and researchers in most areas of pain at high international level. Each country by itself could not have achieved the same broad and deep scientific and clinical opportunities for interactions.

The success story with the very fruitful collaboration and mutually synergistic interactions between the Nordic countries in the Scandinavian Association for the Study of Pain must have been one source of inspiration to Ulf Lindblom when he during the IASP world congress in Paris 1993 invited European IASP chapter-presidents to form a European federation. The intention was to initiate more collaboration and reinforce the aims of IASP in Europe. EFIC was founded in August 1993 with Ulf Lindblom as the first elected President of EFIC.

EFIC became another Ulf Lindblom success: EFIC now comprises 27 IASP chapters from 32 countries with more than 12 000 individual members.

The main goal of IASP has always been to stimulate the study of pain mechanisms and pain management. Since Ulf Lindblom’s president-period, EFIC has had focus on the science of pain. Thus, EFIC has had two very successful activities: the triennial scientific congresses and the scientific journal of EFIC, the European Journal of Pain.

The EFIC scientific congress was first organized in Verona in 1994, the second in Barcelona, 1997, the third in Nice, 2000, and now the fourth in Prague, 2003. There have been an increasing number of attendants, abstracts for free presentations, and a large number of invited plenary and topical seminars lecturers. Clearly, these congresses fill a need for scientific interaction and spreading of scientific and clinical information among basic and clinical pain researchers and practitioners in Europe.

The European Journal of Pain was started by Ulf Lindblom and was first published in 1997 with Ulf Lindblom as Editor-in-Chief. Thanks to a Hereulene and very able effort by him and his deputy Editor-in-Chief and now Editor-in-Chief, Fernando Cervero, this journal rapidly developed into a very successful scientific journal with an impressive impact factor already after its first few years. There is a rapidly increasing number of manuscripts coming into the editorial office every week. These come from basic scientists as well as clinical researchers. Others describe the great impact of his original scientific research in this issue of the EJP.

All of us, who are engaged in pain research and pain management in Europe, and all our patients, owe Ulf Lindblom a great debt of gratitude. This special issue of the European Journal of Pain, printed in his honour, is an attempt to express this gratitude towards Ulf Lindblom for his major achievement in advancing our understanding of pain mechanisms and for improving management of acute and chronic pain not only in the Nordic countries, but also in Europe, and worldwide.

Thank you, Ulf.

Harald Breivik
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Guest Editorial

Ulf Lindblom, the first steps

Ulf Lindblom and I became friends when, as first year medical students, we did our military service at the Royal Naval College. It was impossible to not become attracted by Ulf’s cheerful and absolutely non-military personality. Although we studied at different universities and eventually chose different specialties our friendship continued and has now lasted for almost 60 years. One of our common interests was the nervous system. Ulf as a future neurologist wanted to understand its complexity, and I as a hopeful psychiatrist had the naïve expectation to find the biological substrate of the mind. As fresh doctors we went to see the late professor Carl Gustaf Bernhard who with great courtesy put the resources of his institution at our disposal.

By injecting osmic acid into various parts of the spinal cord we showed in our first experiments that spinal neurons activated by stimulation of low threshold cutaneous nerves were located in the dorsal grey matter and had a considerable longitudinal extension. Previous observations by the English guest researcher David Taverne indicated the existence of descending fibres having an inhibitory influence on the post-synaptic neurons. By spinal sectioning we could record an augmentation of the post-synaptic activity that verified the existence of a descending suppressor pathway. Hemisection of the spinal cord had bilateral effect indicating crossing-over at the segmental level of the descending fibre system. Inhibition of the afferent spinal relay after electrical stimulation of the reticular formation and the pyramidal tract was confirmatory evidence.

We were enormously proud of having our first papers published in 1952 as contributions to a celebration volume to the Spanish neurohistologist Santiago Ramón y Cajal at the centenary of his birth in 1852.

In addition to scientific education our years at the institution of physiology implied training in endurance and patience. Our early cats had a remarkably high premature mortality and we gradually realized that we were performing advanced neurosurgical operations. With envy we looked at the neurosurgeon Einar Bohm at the table next to ours, who could transfer his skill in human operations to animal research. In the late hours at night we often felt a bit abandoned and reacted with a mixture of disappointment and relief when the cat died. Hunger and tiredness put our friendship to hard test but it lasted and deepened.

I do not think that anybody of us missed the animal experiments when we changed to clinical research. Above all it was an alleviation to no longer need to catch the half-wild and spitting cats. It mostly fell to my lot since regretful excuses for being a bit late belonged to the charming points of Ulf.

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Pain questionnaires in the analysis of long lasting (chronic) pain conditions

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Abstract

A study on mainly non-cancer-related pain patients was performed concerning clinical patient data used for pain history-taking and diagnosis. More than 2100 consecutive patients referred to the anaesthetic branch of the Multidisciplinary Pain Centre (MPC) were evaluated at the first visit. The use of a paper questionnaire, including a pain-drawing and pain intensity Visual Analogue Scale (VAS), was analysed. In a substudy of more than 290 consecutive patients, data from a computerised questionnaire and database was analysed. The European Organization for Research and Treatment of Cancer Quality of Life Questionnaires (EORTC QLQ-C30) (version 2.0) was used for recording of the Global Health Status/Quality of Life (GHS/QoL) score. The substudy also included the summarized mechanism-based evaluation of the patients at the first visit, judged by a specialist in pain medicine. The patients' GHS/QoL score was low. The most important pain mechanisms, were nociceptive and peripheral neurogenic. The clinical use of these tools for patient evaluation and for the choice of treatment is suggested. Information technology may be used for analysis of descriptive, evaluative, predictive and prognostic data in pain patients. It can also be used as a tool for clinical pain research towards a mechanism-based evaluation. Evaluation of patient quality of life and function is suitable for outcome research.

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1. Introduction

According to a study from this year, postoperative pain is still significantly undertreated a lot (Bardiaux et al., 2003). We think that this is embarrassing for the medical community as well as the fact that all acute treatable pains should be treated in order to avoid the development of long-lasting (chronic) pains. (Breivik et al., 1996; Katz et al., 1996). Long-lasting pains are suggested to be a big suffering of mankind from an epidemiological point of view (Brattberg et al., 1989; Crombie et al., 1999; Taddio et al., 1997; Tasmuth et al., 1997).

1.1. Pain diagnosis

The strategy for pain treatment ought to be tailored to the pain diagnosis, not to the diagnosis of the disease (Arnér, 2000). The specific clinical pain analysis should replace the routine-like treatment programs such as the World Health Organization (WHO) analgesic ladder, which only refers to pain intensity. A recent call for the development of a mechanism-based classification of pain (Woelfl et al., 1998) gives an aim to this study in suggesting a replacement of the current syndrome-based International Association for the Study of Pain (IASP) classification (Merskey and Bogduk, 1994). We think that chronic pain can no longer be accepted as a single entity for clinical pain research purposes. So, there is a great need for application of new standardised clinical approaches to pain analysis as a mandatory prerequisite for the choice of any type of pain treatment, if specific modulation of the pain itself is the goal (Arnér, 1998).
Pain questionnaires may be such an instrumental approach together with quality of life measurement.

1.2. Types of pain

1.2.1. Nociceptive pain

Nociceptive pain is a form of pain which principally originates from primary activation of nociceptors in somatic, visceral, or nervous tissues, due to a known ongoing pathological process, e.g., neoplastic infiltration, inflammation, ischaemia, visceral stretching, distension, etc. Different algogenic substances may evoke silent nociceptors.

We suggest that common clinical characteristics of individual pain experiences, including time pattern as continuous/intermittent as an expression of breakthrough pains of different origins, may be one part of a specific mechanism as exemplified in Table 1 (cf. Arnér and Arnér, 1985).

In an intact nervous system nociceptive pain is modified by endogenous pain controlling systems (inhibition), the efficacy of which determines the final pain perception. Reflex activity evoked by for example muscle tension and ischaemia may produce secondary and additive nociceptor activation in the periphery. Hyperalgesia may develop following both sensitisation of nociceptors by algogenic substances and wind-up phenomena. Algogenic substances may enhance long-term potentiation of sensitivity to noxious stimuli with the possible involvement of excitatory amino acids, e.g., N-methyl-D-aspartate (NMDA). Different sources of nociception can produce pain with distinctly different clinical characteristics (e.g., somatic, visceral, nerve trunk, and referred pain, see Table 1). The resulting perception of nociceptive pain is further modified by individual tolerance and endurance. Common anti-nociceptive analgesics generally produce effective pain relief in nociceptive pain while neuropathic pains are less sensitive (Arnér and Meyerson, 1988; Matoba, 2001).

1.2.2. Neuropathic pain

This pain is defined by specific criteria associated with functional abnormalities of the nervous system, usually as a result of an injury or a disease process, affecting the peripheral nerves, spinal cord, or brain (Fig. 1). Typically, somato-sensory dysfunction is demonstrated. Such pain is often referred to as neurogenic or neuropathic, and typical examples are neuralgia and other forms of post-traumatic neuropathies. Deafferentation pain is another commonly used term for non-nociceptive pain conditions characterised by more extensive denervation such as anaesthesia dolorosa, phantom limb pain, and plexus avulsion.

Neuropathic pain may be related to ectopic impulses, ephapses, disinhibition, etc. A partial nerve injury may present with Sympathetically Maintained Pain (SMP) or Sympathetically Independent Pain (SIP) (Roberts, 1986).

Allodynia (pain evoked by mechanical or thermal non-noxious stimuli) as well as some forms of hyperalgesia are related to nervous system dysfunction.

Common analgesics are generally inefficacious for these forms of pain, but antidepressants, antiepileptics,

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Table 1
Different forms of nociceptive pain (somatic and visceral), nociceptive nerve pain and neuropathic pain, and some typical clinical expressions and possible pathophysiological mechanisms

<table>
<thead>
<tr>
<th>Tissue origin</th>
<th>Temporal characteristics</th>
<th>Common clinical characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatic tissue</td>
<td>Bone, connective tissue, fascia, muscles, tendons, joints, and skin</td>
<td>Continuous</td>
</tr>
<tr>
<td>Visceral tissue</td>
<td>Viscera</td>
<td>Continuous</td>
</tr>
<tr>
<td>Visceral tissue</td>
<td>Intestinal obstruction and urogenital spasm</td>
<td>Intermittent</td>
</tr>
<tr>
<td>Nervous tissue with intact nervous system</td>
<td>Nerve-trunk (nociceptive nerve pain)</td>
<td>Continuous</td>
</tr>
<tr>
<td>Nervous tissue with intact nervous system</td>
<td>Nerve-trunk (nociceptive nerve pain)</td>
<td>Intermittent</td>
</tr>
<tr>
<td>Nervous tissue with nervous system dysfunction</td>
<td>Peripheral and/or Central Nervous System</td>
<td>Continuous</td>
</tr>
<tr>
<td>Nervous tissue with nervous system dysfunction</td>
<td>Peripheral and/or Central Nervous System</td>
<td>Intermittent</td>
</tr>
</tbody>
</table>
sympatholytic measures, electric stimulation and use of local anaesthetics for nerve blocks or by parenteral and peroral routes may often provide pain relief (Kastrup et al., 1987; Sindrup and Jensen, 1999). In cancer related neuropathic pain, ablative pain surgery may be indicated (Meyerson et al., 1984).

1.2.3. Long lasting regional pain syndromes

1.2.3.1. Idiopathic pain (pain of unknown origin). This is a form of long lasting pain, which cannot be accounted for by any demonstrable organic pathology. The pain may be well localised, but if so, generally without neuroanatomical distribution. It is often more diffuse and refractory to conventional analgesic regimens. The nervous system appears to be intact. Sometimes idiopathic pain has started as a result of trauma or disease process, but there is a striking disproportion between reported suffering, remaining symptoms, and physical signs. This form of pain often perpetuates as a Somatoform pain disorder (Imbierowicz and Egle, 2003). Generally no obvious psychiatric disease can be diagnosed although personality traits of depression and neuroticism may be revealed by psychological tests.

Commonly, patients with idiopathic pain have consulted a number of specialists and have been subjected to numerous diagnostic procedures without positive organic findings. The pain in this group may only be defined according to its location.

Idiopathic pains are commonly non-responsive to both pharmacological (Arnér and Meyerson, 1988) and other treatment modalities (Thomas et al., 1992). Neither anaesthetic nor neurosurgical treatment modalities are successful.

Our MPC includes rehabilitation medicine involving treatment modalities that are better suited for this group of patients.

1.2.3.2. CRPS type 1 or 2 (dysautonomic pains). Complex Regional Pain Syndrome (CRPS) is a specific type of neuropathic or nociceptive pain with trauma as the most common origin. Nerve damage may be defined in some cases (type 2). Sometimes those types of pain are SMP, sometimes not. If SMP, sympathetic blocking procedures can be used both diagnostically and as a treatment modality (Arnér, 1991a, b).

1.2.3.3. Psychogenic pain. This is a typical pain caused by psychiatric illnesses, which need psychiatric expertise in a multidisciplinary pain organization.

1.3. Pain questionnaires

Pain questionnaires have been frequently used in the analysis of pain (Keefe et al., 1992; Klepstad et al., 2002;
Roelofs et al., 2003; Wright et al., 2001). Our own formula, the Karolinska Hospital Pain Questionnaire has been used continually since 1977 when Ulf Lindblom, now retired, was an important collaborator in our MPC and had strong influence on the clinical development and instrumental approaches to pain analysis (cf. Lindblom, 1993).

Originally, our questionnaire was meant to analyse descriptive, evaluative, predictive and prognostic potentials (Carlsson, 1984). It was adopted by us and re-designed to be used in the anaesthetic branch of the MPC at the Karolinska Hospital. Later the neurosurgical branch of the same MPC has also used it. Since 1993 it has been a free tool from the pharmaceutical company AstraZeneca Sweden, in Swedish and to be used by anyone cost-free.

The aim to use pain questionnaires was based on a clinical empirical suggestion that:

1. Traditional history-taking procedures do not routinely focus on the multidimensional nature of a pain experience.
2. Relevant information must come directly from the patient. Asking for a patient’s own opinion is of particular importance concerning pain development over time.
3. In the hands of a trained doctor it helps the patient to define his/her experiences.
4. Different procedures in pain assessment, as descriptor analyses and pain rating are routinely performed and documented and is instructive both for the doctor and his patient.
5. Serves as a checklist to avoid missing any important information.
6. Can be the subject for computerised work-up.
7. May be a source for outcome studies.

The pain questionnaire comprises demography, history of pain, and present status of the pain and it was applied in more than 2000 consecutive chronic pain patients, referred from primary or specialist care in our region. It also included information on aetiology, location and time pattern of the pain, past and present treatments, and their effects. In the questionnaire, the location, distribution and quality of pain are presented in a pain drawing, which also includes pain descriptors. Furthermore, the questionnaire contains a VAS in which the patients are asked to point out the pain intensity as its worst and best levels, respectively. This variation is verbally analysed in relation to a number of pain correlates (e.g., activity, temperature, touch, emotions, etc) or pain relieving factors (e.g., medication, rest, temperature, and emotions).

The patients’ attitudes to their problems, emotional and physical responses to work, activities and social life are also noted. Finally the types of pains are also categorised from a mechanism-based point of view.

From a mechanism-based point of view, chronic pain is not a single entity. This has been discussed in several papers recently (Arnér and Meyerson, 2000; Moore et al., 1998; Woolf, 2000). Differentiation between nociceptive and neuropathic pain is not a fully established routine in our society (Hansson and Kinanam, 1996). In this context, Ulf Lindblom has been a great pioneer in the analysis of neuropathic pain (Berglund et al., 1997; Lindblom, 1980, 1985, 1993; Lindblom and Hansson, 1991; Lindblom and Vercillo, 1979). As the tutor of one of the authors of this paper (SA), Ulf Lindblom has influenced us to use instrumental approaches to clinical pain analyses such as identification of different pain mechanisms by means of pain questionnaires and mapping of somato-sensory dysfunction. The PhD thesis on “Differentiation of pain and treatment efficacy” (Arnér, 1991a, 1991b) was also supervised by Björn Meyerson, also one of the main pioneers in the treatment of neuropathic pain conditions (Meyerson and Häkansson, 1986; Meyerson, 1990, 1997; Meyerson et al., 1993, 1995). Our routines to use pain questionnaires were followed by an aim in every single patient to suggest the specific pain diagnosis with differentiation in order of precedence for the type of pain that was most relevant in causing the patient’s suffering (cf. Lindblom, 1993).

Routine mechanism-based analytical methods in Sweden also include pharmacological tests (Arnér, 1998).

1.4. Computerised pain questionnaire

A computerised questionnaire has been used for all patients in our clinic since 1996. The computerised questionnaire PainScreen (Janssen-Cilag, Sweden) is developed from the Karolinska Hospital Pain Questionnaire. It comprises administrative measures, demography, pain diagnostic data, and pain assessment including VAS. PainScreen also includes two different health-related quality of life measure concepts, the EORTC QLQ-C30 (version 2.0) and the SF-36 (Medical Outcomes Study 36-item Short Form Health Survey). Classification of pain can be made both according to the IASP classification and to the mechanism-based pain diagnostic standard developed by one of the authors (Arnér, 1998).

EORTC QLQ-C30 is a questionnaire, which was developed and recommended for use among cancer patients and not intended for health related quality of life (HRQOL) assessments in the general population (Aaronson et al., 1993; Hjermstad et al., 1998).

The database is a Microsoft Access database and the entry of data is made by means of a touchscreen or by ordinary personal computer entry.

The aim of this study was to analyse the quality of the patient questionnaire data used for history-taking and diagnosis of about 2000 pain patients.
2. Materials and methods

2.1. Patients

2.1.1. Paper questionnaire

The paper questionnaire data was collected on all patients during 1982-2002, from the patients at the first visit to the outpatient clinic at the anaesthetic branch of the MPC, Karolinska Hospital, Stockholm. The majority of patients had long-lasting non-cancer-related pains. Relevant medical and surgical investigations and treatments were completed prior to referral to the MPC. The referrals to the MPC are handled within the Karolinska Hospital Multidisciplinary Pain Group (MPG) that consists of members from nine different medical specialties who are also pain medicine specialists (Anaesthesia, Clinical Pharmacology, Neurology, Neurosurgery, Orthopaedic Surgery, Paediatric Anaesthesia, Psychiatry, Rehabilitation Medicine, and Rheumatology). This type of organization has been proven to be better than single-handed practices (Flor et al., 1992).

2.1.2. Subgroup computerised questionnaire

A substudy using the computerised questionnaire was performed alongside the main study from 1999-2002 and data was collected consecutively. This group of patients is a subgroup of the patients in the paper questionnaire group that have filled in both the paper questionnaire and the computerised questionnaire.

2.2. Study design

The study is a qualitative control of clinical patient questionnaire data used for history-taking and diagnostic purposes, monitoring patients mainly with long-lasting non-cancer-related pains at the first visit at the anaesthetic branch of the MPC.

2.3. Multidisciplinary pain centre intervention

The staff at the anaesthetic branch of the MPC at the Karolinska Hospital in Stockholm consists of four pain medicine specialists (anaesthesiologists), one physiotherapist, one social worker, four pain nurses, and one secretary (Thomsen et al., 2002).

A pain specialist performed the initial evaluation.

2.4. Assessment methods

2.4.1. Paper questionnaire

Data on individual patient’s pain related health status including pain intensity VAS was measured and collected through a paper questionnaire posted at referral, prior to the first consultation.

2.4.2. Subgroup computerised questionnaire

The patients that participated in the instrumental approach were helped by a pain nurse to answer the computerised questionnaire. This took about 15 min and occurred before the first consultation. Pain intensity VAS was measured and so was the score for the EORTC QLQ-C30 (version 2.0).

2.5. Procedure

2.5.1. Paper questionnaire

The paper questionnaire comprises a pain drawing and 45 other items concerning demographic data, occupational and social status, quality of life related questions, and more pain related questions as pain characteristics, temporal pain profile and analgesic efficacy. The paper questionnaire also includes pain intensity at max (maximum) and min (minimum) using a pain-VAS.

2.5.2. Subgroup computerised questionnaire

The computerised questionnaire also included the EORTC QLQ-C30 (version 2.0) and the SF-36, two different health-related quality of life measure concepts.

EORTC QLQ-C30 (version 2.0) assesses HRQOL with five functional scales (physical functioning, role, emotional, cognitive, and social), a GHS/QoL scale and nine symptom-oriented scales (fatigue, nausea and vomiting, pain, dyspnea, sleep disturbance, appetite loss, constipation, diarrhea, and financial difficulties). The range for each subscale is 0-100. For the functional scales and the GHS/QoL scale, a higher score represents a better level of functioning and for the symptom-oriented scales, a higher score corresponds to a higher level of symptoms (Aaronson et al., 1993).

The database also contains classification of pain according to IASP and a pain diagnosis system developed by one of the authors (SA) with a mechanism-based differentiation of pains with concluding remarks in precedence from 1 to 3 on which mechanism is most relevant for the patient’s suffering. (Arnér, 1998).

2.6. Statistics

Data as median or percentage of the total number of patients (males and females) are reported in the text, tables, and figures.

The paper questionnaire data was manually extracted from the questionnaires to a Microsoft Access database and there the data was further handled.

Some data was extracted directly from the computerised questionnaire and some data was transferred from the computerised questionnaire to a separate Microsoft Access database to make it possible to do further analyses. Supposed clinically relevant questions were selected.

Descriptive analyses of data for patients were performed.
3. Results

3.1. Patients

3.1.1. Paper questionnaire
All patients completed the paper questionnaires on the day of the first visit.
2111–2200 questionnaire items were analysed, out of a total of 2231 questionnaires.

3.1.2. Subgroup computerised questionnaire
293–294 questionnaire items were analysed, out of a total of 305 records.
The patient collaboration was excellent, both for the main group and the subgroup.

3.2. Demographic data

3.2.1. Paper questionnaire
The median age for women was 56 years and for men 54 years.
Sixty-four percent of the patients were women.
Thirty-five percent of the patients were 65 years or older.

3.2.2. Subgroup computerised questionnaire
The median age was 60 years for men and 58 years for women.
Sixty-seven percent of the patients were women.
Thirty-eight percent of the patients were 65 years or older.

3.3. Pain duration

3.3.1. Paper questionnaire
The time between the start of the pain and the first visit was 0→120 months, with a peak at 24–48 months.

3.4. Number of pain types according to the patients

3.4.1. Paper questionnaire
Sixty-three percent of the patients reported several pain types to be coexisting.
Twenty-five percent of the patients reported an unspecified type of pain.

3.5. Temporal pattern of pain

3.5.1. Paper questionnaire
Fifty-five percent of the patients had pain continuously when awake.
Thirty-five percent of the patients could be painfree one or more hours with or without treatment.
Two percent of the patients had painfree weeks.
Twenty-four percent of the patients reported that their pain became worse spontaneously.

3.6. Origin of pain according to the patients

3.6.1. Paper questionnaire
Forty-six percent of the patients reported pain origin as surgery, medical investigation or other medical care.
Forty-one percent of the patients reported pain origin as linked to a disease. Twenty-eight percent of the patients reported pain origin as related to an accident.
Seventeen percent of the patients reported pain from an accident at work. Fifty-one percent of the patients reporting pain from an accident at work, were men.
Twenty-five percent of the patients knew nothing about the origin of the pains.

3.7. Pain medication

3.7.1. Paper questionnaire
The patients reporting a good painreduction with continuous pain medication, had a median VAS max 70 mm and median VAS min 10 mm for men and for women it was 90 and 13 mm, respectively.
For the patients reporting no painreduction with continuous pain medication, the median VAS max was 78 mm and median VAS min was 45 mm for men and for women it was 90 and 52 mm, respectively (Table 2).

3.8. Non pharmacological treatment efforts/complimentary treatments

3.8.1. Paper questionnaire
Seventy-three percent of the patients had tried modality oriented treatment methods such as Transcutaneous Electrical Nerve Stimulation (TENS), physiotherapy and acupuncture, without meaningful effects.

Table 2
Analgesic therapy and patients VAS rating for the main group (paper questionnaire)

<table>
<thead>
<tr>
<th>Continuous pain medication and patients rating &quot;good painreduction&quot;</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS MAX (0–100 mm)</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>VAS MIN (0–100 mm)</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Continuous pain medication and patients rating &quot;no painreduction&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAS MAX (0–100 mm)</td>
<td>78</td>
<td>90</td>
</tr>
<tr>
<td>VAS MIN (0–100 mm)</td>
<td>45</td>
<td>52</td>
</tr>
</tbody>
</table>
3.9. Health related quality of life

3.9.1. Subgroup computerised questionnaire

In the sub-study, HRQoL was measured using the instrument EORTC QLQ-C30 (version 2.0). The median GHS/QoL score was 33, both for women and men (Fig. 2).

The patients with a low median GHS/QoL score, was the patientgroup that had the highest median VAS min values. The patients with high median GHS/QoL score, had the lowest median VAS min values (Fig. 3).

![Graph showing GHS/QoL score vs. Total N](image)

**Fig. 2.** EORTC GHS/QoL score for the subgroup (computerised questionnaire). A higher score (0-100) represents a better level of functioning.

![Graph showing VAS max vs. VAS min](image)

**Fig. 3.** EORTC GHS/QoL score vs. recorded VAS max and VAS min (0-100 mm) for the subgroup (computerised questionnaire).

Table 3

<table>
<thead>
<tr>
<th>Most important</th>
<th>2nd in importance</th>
<th>3rd in importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nociceptive</td>
<td>140</td>
<td>44</td>
</tr>
<tr>
<td>Peripheral neurogenic</td>
<td>116</td>
<td>35</td>
</tr>
<tr>
<td>Central neurogenic</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Dysautonomic</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Psychogenic</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Evaluations of 293 consecutive patients at their first visit, judged by a specialist in Pain Medicine (subgroup, computerised questionnaire).

3.10. Pain diagnosis

3.10.1. Subgroup computerised questionnaire

The most important pain mechanisms were nociceptive and peripheral neurogenic. No patients were primarily diagnosed as having psychogenic pain (Table 3).

4. Discussion

4.1. Conversion from acute to long lasting pain

This is another clinical study, which gives some evidence to the hypothesis that chronic pain develops from poorly treated acute pains and long-term potentiation as a probable mechanism (Fagg et al., 1986).

Long-lasting pain is thus also composed of a number of definable components from a mechanism-based point of view. Our investigation of more than 2100 consecutive chronic pain patients with different temporal pain patterns, shows that in 46% the origin of the pain is medical procedures, that is to say an iatrogenic origin. This is the first study to show such a frequent conversion from acute to long lasting pain in non-malignant pains. The overall treatment of post-operative pain has not really improved, according to recent information (Bardiau et al., 2003; Rawal, 2002). The discussion on whether surgical painful procedures in health care really are necessary or not must be highlighted. Anaesthesia must be prepared to take an increasing role in this area. This also underlines the need for more evidence based demands on surgical or anaesthetic procedures for pain relief such as for example back pain surgery, lesional blocks, etc. The scientific basis for more than 30 different treatments was systematically reviewed in the Swedish Council on technology assessment in health care. For the majority of these there are either no evidence or limited evidence in favour of treatment. For some modalities there is strong or moderate evidence against their effectiveness, e.g., by traction, aerobics, stretching, and bed rest. For a minority of treatments there is strong evidence of effectiveness, e.g., for anti-inflammatory and muscle relaxant drugs, manual treatment, manipulation exercise, multidisciplinary treatment, and continuation of normal activities (Nachemson et al., 2000). This has already been pointed out by others and the number of patients is certainly crucial to make the statistics and the validation more appropriate (Moore et al., 1998).

The high frequency of pain after surgical interventions has also been discussed earlier (Macrae, 2001). This investigation highlights the urgent need for better routines with quality assurance standards for acute pain treatment. In Sweden, an unnecessary pain is officially classified as a non-acceptable incident. This message to many basic specialties is very clear and should
especially be noticed when for example treatment of low back pain is concerned (Nachemson et al., 2000).

A recent survey suggests that compliance with published practice guidelines for acute pain management can be improved (Wilder-Smith et al., 2002).

4.2. Pains related to unknown origin

Another important finding in our study of more than 2100 consecutive long lasting pain patients revealed that 25% of the patients did not know about the origin of their pains, "they just came from one day to another". Pain is part of life and relatively often of undefinable origin, thereby impossible to classify from a mechanism-based point of view. We have to realise this phenomenon and suggest a more active and more available modality oriented treatment standard for those patients by means of cognitive behavioural therapeutic interventions such as earlier recommended (Buer et al., 2002; Fordyce, 1976; Linton et al., 1984) and other evidence based therapeutic interventions (McQuay and Moore, 1998; Morley et al., 1999).

Unexplained severe chronic pain in general practice has been analysed by others (Kerssens et al., 2002; cf. Imbierowicz and Egle, 2003). The prevalence estimate in general practice was 7.91 per 1000 patients compared to our 25% per 2000 patients. The fact that more than 60% of our 2000 patients could be defined as having more than one type of pain tells us that developing pain analysis from a mechanism-based point of view in order to differentiate between all pains is an urgent matter.

4.3. Temporal patterns of pains

The investigation revealed that 55% of the patients were in constant pain whilst awake. Of these patients a significant part had filled in that they did not know the cause of the pain.

35% had experienced a pain free hour and that was most often due to the use of pain medicine. Two percent of the patients had a temporal pattern including complete pain relief for about a week.

Twenty-four percent of the patients had no known correlates aggravating or easing pain. This illustrates that many patients have no strategies in controlling the pain experience such as altered movement or other relieving strategies. This seems more common in pains without known origin and gives no indication as to whether specific physiotherapy should be recommended or not.

4.4. Treatable pains

We also tried to compare the temporal pattern of pains responding to the use of analgesics and their effect. A Total of 1209 patients (55%) experienced resistance to common analgesics also indicating a frequent insensi-

tivity to at least common antinociceptive drugs in escalation according to the WHO analgesic ladder. A reconsideration of this insufficient pain treatment standard has recently been discussed (Arnér, 2000).

4.5. Quality of life

When quality of life is concerned, it was possible to find out that our patients overall had a low quality of life, which might be expected for disabled patients. The median GHS/QoL score 33 for both women and men measured with EORTC QLQ-C30 (version 2.0), is worse than mean scores observed in Norway for patients with "cardiac problems" (58.0), cancer (including cancer survivors) (59.9), "chronic disease" (66.1), and "people reporting no health problems" (86.6) when measured with EORTC QLQ-C30 (+3). At the same time one has to be cautious, when interpreting scores from people suffering from different diseases (Hjermstad et al., 1998).

Our analysis of quality of life was made with the EORTC-instrument, which was developed and recommended for use among cancer patients. In oncology and palliative medicine a lot of treatable pains are obvious. There are for example data that more than 30% of all cancer patients suffer from neuropathic pains (Bruera et al., 1995) and for those patients the SF-36-method may be a better instrument. (Meyer-Rosberg et al., 2001a, b).

The most interesting results were the differences between patients with a high and low quality of life. It was obvious that in the group of high quality of life-patients, it was more common that patients could experience a score of zero as expressed on the visual analogue scale. That is, a freedom from pain at least periodically was correlated to some type of treatment, positioning, or other correlates. Whether the extreme point zero is significant as a negative predictor for patients from the category of idiopathic pains has still to be analysed, but is suggested to be a positive predictor in patients with pains, definable from neurobiological point of view and hence hopefully sensitive to some sort of directed pharmacological interaction.

4.6. Mechanism-based evaluation

The finding that 63% of the more than 2100 patients with long-lasting pain also reported an experience of more than one type of pain underlines the need for differentiation of pain components in any pain patient. Cancer Pain, Post-Operative Pain and Acute Pain ought to be better defined from a mechanism-based point of view. In order to discuss different pain mechanisms it has also been suggested in the current literature that pharmacological pain analyses may catch a single mechanism (Arnér, 1998).

We used this computerised methodology in order to describe a mechanism-based evaluation of 293
consecutive patients in the series at the first visit, judged by a specialist in pain medicine. In Table 3 it is possible to look into the mechanism-based pain evaluation for those patients. As may be seen there, the nociceptive pains are most common as the first cause of suffering in most cases. Nociceptive pains are easiest to treat by means of anti-nociceptive pharmacological principles, while neuropathic pains are more amenable to completely different treatment procedures, especially by means of multidisciplinary intercollaboration with Neurology (Hansson et al., 2001) and Neurosurgery (Meyerson and Håkansson, 1986; Meyerson et al., 1993, 1995). When pain mechanisms are found as nociceptive and neuropathic, it is most often possible to modulate the pain experience by means of pharmacological therapy and modern techniques for, e.g., non-pharmacological methods (Malone and Strube, 1988).

4.7. Education

This study also underlines the need for better education in advanced pain medicine. Such education was supported internationally by the former president of IASP, Ulf Lindblom (Fields, 1995) and has now also started within the Scandinavian Society of Anaesthesiology and Intensive Care Medicine (SSAI) (Breivik and Lindahl, 2001).

In Sweden, pain medicine has been a certified specialty since 1997 and Ulf Lindblom is the first honorary member of the Swedish Association of Pain Specialists.

In conclusion chronic or long-lasting pain conditions seems to be commonly related to inefficient methods for the control of acute pain. This embarrassing iatrogenic interaction in a society of increasing absence from work due to disability and illness, makes this study an important reminder of the need for better approaches for qualitative assurance standards for acute pain management. The fact that 46% of our patients think that their pains started within health care after surgical or diagnostic procedures with bad pain relieving standards is obvious. Similar suggestions are found in a recent article (Bardiau et al., 2003). We recommend the avoidance of bad treatment standards for acute pain utilising better routines, which are continuously followed up by audit.

New strategies should be focused on the prevention of chronic pain by means of avoiding central sensitisation of pain (Malmberg et al., 2003). The known effect that psychosocial interactions may follow the imprinting of pain to a chronic disease of its own, demands better instrumental approaches to pain analysis (Flor et al., 2002). Our study confirmed that 63% of all chronic pain patients in our series suffered more than one pain type, which is also the best evidence to confirm the need to leave “chronic pain” as an entity for clinical pain research protocols. Chronic pain is never a single entity (Arner and Meyerson, 2000; Woolf et al., 1998). The patients’ quality of life score was low measured with the instrument EORTC QLQ-C30 (version 2.0).

Acknowledgements

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References


Mills RJ, Cahill DJ, Tramer M, Collins S, McQuay H. Size is everything: large amounts of information are needed to overcome random effects in estimating direction and magnitude of treatment effects. Pain 1998;78:209–16.


Master scaling of perceived intensity of touch, cold and warmth

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Abstract

A new approach is presented for scaling perceived intensity of touch, cold and warmth based on magnitude estimation. In this method named master scaling thenar is utilized as common reference area for scaling and calibrating perceived intensity. The master scaling is particularly well suited for clinical applications in which the stimulation in pain-affected body areas creates a complex perception (e.g., paradoxical heat for cold stimulation) and/or aberrant psychophysical functions for perceived intensity. The results from three different experiments showed that: (a) All patients and healthy subjects were able to scale adequately the perceived intensity of touch, cold, and warmth at unaffected body areas. (b) Thenar stimulations were shown to be adequate common references in the joint scaling of perceived intensity of other body areas in pain patients as well as healthy persons. (c) Individual thenar psychophysical functions can be used for screening patients and healthy persons with regard to their ability to scale perceived intensity of touch, cold and warmth. (d) Master scaled perceived intensity scales can be used for determining if various pain-unaffected body areas are normal or abnormal in patients and in healthy persons. (e) The interindividual variation in perceived intensity is considerably reduced after master scaling and approaches that of intrindividual variation as found in olfaction and hearing. Finally, empirically based thenar Master Functions of perceived intensity for touch, cold and warmth are proposed to be used in future sensory testing of patients, as well as of healthy persons.

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Keywords: Pain syndromes; Warmth; Cold; Touch; Perceived intensity; Master scaling; Comparability

1. Introduction

Each patient with ongoing pain may have a unique sensorium dominated by his or her pain condition. We would expect that experience and awareness of the ongoing pain would exert influence on cutaneous perceptions. Sensory dysfunctions in the perception of touch, cold and warmth are well known in neuropathic pain patients, although research has not managed to show a systematic relationship between the intensity of ongoing pain and the type of sensory dysfunction (hypo- or hyperesthesia). It seems that each patient with ongoing pain is unique and, therefore, his or her cutaneous perceptions may best be assessed in case studies. One great challenge of such case-study research is to create comparability of perceptual scales between unique patients. In the following, we will present the method of master scaling of perceived intensity and demonstrate its usefulness for calibrating perceptual scales originating from different body areas in patients with different pain conditions as well as in healthy individuals. The experimental design constitutes a fundamental part of the method of master scaling. Somewhat daringly, we pursue that comparability is obtained by calibrating patients’ sensoria with regard to perceived intensity of touch, cold or warmth.

It is somewhat puzzling that there has been little interest in establishing a unit of measurement of perceptual scales and, thus, provide comparable scale values (for an exception, see Borg, 1998). Particularly, scale units have to be known in order to make meaningful comparison of scales derived from one person or another. In physics, scales of instruments are typically calibrated to a common scale before each instrument is used for measuring a quantity. Such calibration is postulated by the in-built principle of the measuring instrument. For example, for temperature the principle of
mercury enlargement will be the same in all thermometers and, therefore, individual temperatures can be marked similarly on thermometers of somewhat different design. In perceptual measurement, there are also in-built principles as, for example, the growth of perceived intensity with bending pressure of von Frey filaments. Typically, this growth function can be described as a power function, which reflects the operating characteristics of the sensory system of touch (Mountcastle, 1967; Berglund et al., 1997, 2001; Berglund et al., 2002). However, different persons will not produce exactly the same power function with invariant constants, rather large interindividual differences may occur.

Whereas differences between readings of thermometers are viewed as errors of measurement, corresponding differences between persons' scales of perceived intensity might only partly be referred to such errors. Ekman and Sjöberg (1965) point out that a variation in magnitude estimation scales, which typically are used in obtaining power functions for perceived intensity, may be interpreted in at least two entirely different ways (cf. Baird, 1997): (a) It may reflect response bias, a kind of error in the subject's handling of the numbers. The true perceptual scale remains invariant, but the numerical estimates produced by the subject are distorted. (b) It may reflect a genuine sensory physiological effect. The true perceptual scale is really affected just like other kinds of responses, for example, the effect may be due to differences in sensory adaptation that are genuine.

Most of the research on direct scaling methods (e.g., magnitude estimation, category scaling, visual analog scaling) has accepted the first way of thinking, often implicitly assuming that the measuring instrument is a "standard observer" with an in-built principle similar to a "fixed ruler". Few have tried the second way of thinking including an assumption of "dynamic" perceptual systems. That is, to accept interindividual variation as reflecting true perceptual differences between individuals. Instead of postulating that different persons use the scales provided by experimenters in exactly the same way, we may assume that they produce a perceptual scale which is continuously changing with experimental context and perceptual experiences, and the scale values you read off vary accordingly.

It is well known that perceptual scales are affected by contextual factors, such as the selection of stimuli, in particular their spacing, range and the use of a standard stimulus (e.g., Ekman and Sjöberg, 1965; Birnbaum, 1982; Mellers and Birnbaum, 1982). However, the variability in numerical scales remains even if some of these systematic effects are removed (Teghtsoonian, 1973). With the development of joint scaling contexts (Berglund et al., 1974; Stevens, 1976), it has been shown that also qualitative differences in the set of stimuli may affect scales of perceived intensity. Marks (1988) named this contextual bias, a concept that indeed reflects a pre-conceived opinion about the effect. However, a bias may be in favor of or against an idea. The variation in magnitude estimates of perceived intensity presumably results largely from differences in the way people use numbers (e.g., Parducci, 1974; Birnbaum, 1982; Algol and Marks, 1984; Baird et al., 1991) and some of the variation certainly has a sensory origin (Luce, 1972; Schneider and Parker, 1990).

The present methodological study presents a new approach to the scaling of perceived intensity of touch, cold and warmth based on magnitude estimation. Earlier experiments have used healthy subjects without signs of sensory dysfunctions or ongoing pain condition. Examples are the perceived intensity of warmth (Stevens and Stevens, 1960; Stevens and Marks, 1971; Stevens et al., 1974; Feine et al., 1991; Tursky et al., 1982) and of cold (Stevens and Stevens, 1960; Marks and Stevens, 1972; Chery-Croze, 1983). Other examples are found for vibration (e.g., Stevens, 1959) and for pain elicited by electric shocks (e.g., Rollman and Harris, 1987; Lautenbacher and Rollman, 1993).

1.1. The principle of Master Scaling

Master Scaling was developed in order to be able to obtain one perceptual measurement from one person at one occasion and be able to compare it to one perceptual measurement from another person at another occasion. This comparability is a need in many environmental field studies (Berglund et al., 1974, 1986, 1988; Berglund and Lindvall, 1979; Berglund et al., 1983, for description see Berglund, 1991, 1995). Valuable uses of master scaling are presented in Berglund and Nordin (1990, 1992).

The Principle of Master Scaling views perceptual measurement as context and experience based dynamic processes. It utilizes both the perceptual and the handling-of-the-numbers variations in the magnitude-estimation measurement. The main purpose of Master Scaling is to construct a calibrated scale from magnitude estimates given by different individuals. The basic assumption is that the perceptual measurement works as if we were measuring with an elastic medium (like a rubber band) whose characteristics are yet unknown. To obtain comparable measures, within an individual and between individuals, it seems obvious that the elastic medium has to be held constant in elasticity while the measurement is performed. Thus, a constant experimental context has to be accomplished in the experiment so that the elasticity may be assumed to be invariant. However, for the different individuals, this contextually based (with references), experimentally accomplished elasticity is constant but different. Thus, the individual scales cannot be compared before the scales have been calibrated to a common reference scale or the Master Scale. This calibration has to be based on a model for the transfer in
elasticiy. A simple model tried so far states that magnitude estimates give scales of relative ratios, and that a power group transformation is needed for calibrating individual scales to a common perceived intensity scale for a set of common references.

Five steps are involved in the Principle of Master Scaling (e.g., Berglund, 1991, 1995) to be applied for touch, cold and warmth: The first step is to create an experimental setting for a perceptually controlled scaling of perceived intensity with the method of free-number magnitude estimation. The second step is to derive calibration constants for each person by fitting power functions to their individual data sets of perceived intensity for a set of common reference stimulation. The third step is to select a theoretically or empirically derived Master (power) Function relating perceived intensity to the physical reference continuum. The fourth step is to calibrate the target empirical perceived intensity values to the Master Scale of perceived intensity with the aid of the transformation factors obtained from the individual power function and the Master (power) function for the reference. The fifth step is to compare in an absolute sense the Master Scale values of target perceived intensity that is read off on the identical scale (possible to standardize). Please note that Master Scaling does not require any knowledge of a physical continuum for the target, however, in the present application such continuum exist for touch (bending pressure in gram), cold and warmth (temperature in K or °C).

The master scale transformation is as follows for touch. The perceived intensity is a simple power function of bending pressure

\[ R = cS^n, \]  

where \( R \) stands for perceived intensity, \( S \) for stimulus intensity, \( c \) is the multiplicative constant and \( n \) is the exponent (e.g., Stevens, 1957, 1975). Let this equation for the Master Function of the references be subscribed by \( m \).

\[ R_m = c_mS^{n_m}. \]  

Let the equation for the empirically obtained perceived intensity for the references for each individual be subscribed by \( i \),

\[ R_i = c_iS^{n_i}. \]  

Because the physical measures are the same, \( S = S_i \), in Eqs. (2) and (3), equating the two and rearranging the terms give the formula for the Master Scale Transformation

\[ R_m = c_m(R_i/c_i)^{n_i/n_m}, \]  

where \( R_i \) is the empirical perceived intensity of the reference and \( R_m \) is this perceived intensity transformed to the Master Scale. By inserting the individual empirical perceived intensity values of the target stimuli (\( R_i \)) into Eq. (4), these can be transformed to the unit and reference points of the Master Scale of perceived intensity (\( R_m \)), defined for the set of reference perceived intensities.

For the perceived intensity of cold and warmth, the power function includes a constant for the extrapolated threshold (\( S_0 \)), such that the function for cold is

\[ R = c(S_0 - S)^n \]  

and the function for warmth with its extrapolated threshold (\( S_0 \)) is

\[ R = c(S - S_0)^n. \]  

Please note the different direction of the correction for the two different extrapolated thresholds (\( S_0 \)) in the warmth (Eq. (6)) and cold (Eq. (5)) modalities, respectively. The perceived intensity of warmth increases with increasing temperature (Eq. (6)) whereas the perceived intensity of cold increases with decreasing temperature (Eq. (5)).

Let the constants and variables of the Master (power) Function for the references be subscribed by \( m \), and let the corresponding constants and variables empirically obtained from the individual power functions for the references be subscribed by \( i \). These two power functions, subscribed \( i \) and \( m \) are according to Eq. (5) for cold and according to Eq. (6) for warmth. By setting \( S \) equal in the individual power function (subscript \( i \)) and the master power function (subscript \( m \)) of Eq. (5), the individual perceived intensity of cold (\( R_i \)) may be transformed to the perceived intensity of the master scale for cold (\( R_m \)) using the following equation:

\[ R_m = c_m(S_{0m} - S_{0i}) + (R_i/c_i)^{1/n_i}S_{0m}. \]  

Correspondingly, Eq. (6), which is the power function for perceived intensity of warmth, results in the following equation for master scale transformation:

\[ R_m = c_m(S_{0m} - S_{0i}) + (R_i/c_i)^{1/n_i}S_{0m}. \]  

Please note that the Master Scale Transformation for cold (Eq. (7)) and warmth (Eq. (8)) only includes constants derived from psychophysical power functions for the set of references. Thus, the two extrapolated thresholds (\( S_{0m} \) and \( S_{0i} \)) in each equation refer to the reference stimulation for each modality (Eq. (5) or Eq. (6)).

Kelvin’s or Celsius’ temperature scales may be used in Eqs. (5) and (6) (e.g., Stevens and Stevens, 1960). After correcting for extrapolated threshold, the perceived intensity may be plotted against the scale values of either of the two temperature scales. The absolute size of the extrapolated threshold difference, \( (S_{0m} - S_{0i}) \) for cold and \( (S_{0i} - S_{0m}) \) for warmth in Eqs. (7) and (8), will also be the same in both Kelvin and Celsius temperature scales. Eqs. (7) and (8) are used for the master scale
transformation, that is, for transforming any \( R_i \) value to the common Master Scale of perceived intensity \( (R_m) \) provided each participant's three unique constants \((s_0, c_1 \text{ and } n_1)\) are used.

1.2. Problem and aim of study

In order to control for experimental context effects and individual unique persons' perceptual competence, the Master Scaling Principle (Berglund, 1991, 1995) has been applied in several experiments conducted by the authors on the perception of touch, cold and warmth in chronic pain patients and healthy persons. Comparability in scale values of perceived intensity in the three modalities is sought within and between subjects at different testing occasions. This is accomplished by scaling each subject's perceived intensity at a reference body area stimulated and scaled alternately with the target body areas in the experimental design. By conducting the Master Scale Transformation separately for each participant, the experimental context as well as the unique perceptual competence will be adequately controlled when different participants' body areas are scaled at different occasions.

The overall aim of this article is to evaluate the potential and limitations of the Master Scaling procedure for calibration of perceived intensity scales of touch, cold and warmth in pain patients and in healthy persons. Main components of this evaluation are:

(a) Are thenar stimulation adequate references in the joint reference scaling of perceived intensity of other body areas in pain patients as well as healthy persons?

(b) Are the individual thenar psychophysical functions possible to use for screening patients and healthy persons with regard to their ability to scale perceived intensity of touch, cold and warmth?

(c) Are the Master Scaled perceived intensity scales possible to use for determining if various pain-unaffected body areas are normal in patients and in healthy persons?

Another, secondary aim is to propose empirically based thenar Master Functions of perceived intensity for each of the thee modalities touch, cold and warmth.

2. Methods

2.1. Subjects

In all, 21 neuropathic pain patients (10 women and 11 men, 32–80 years), 20 fibromyalgia syndrome (FMS) patients (women 30–60 years) and their age-matched healthy controls, as well as 48 healthy men and women (half of each gender: 20–30 years or 55–65 years) have participated in experiments designed for master scaling of perceived intensity for touch, cold or warmth with thenar as reference area (touch not studied for the 48 healthy persons), (Berglund et al., 2001; Berglund et al., 2002; Harju, 2002). Each patient participated in four sessions in four different days, and all healthy persons participated in two sessions covering one or two days. The outpatients with neuropathic pain and FMS had a definite pain diagnosis due to peripheral \((n=12)\) or central \((n=9)\) lesions and due to fulfilling FMS criteria \((n=20); Wolfe et al., 1990\), respectively. The healthy participants were recruited from random samples of inhabitants in the Greater Stockholm area. All outpatients were treated by Karolinska or Danderyd Hospitals, Sweden, and they (and the controls) abstained from analgesics in connection with the experiment. The experiments were approved by the local ethical committee of the Karolinska Institutet and all patients (and their controls) gave their informed consent.

2.2. Tactile and thermal stimulation

Thirteen von Frey nylon filaments (Aesthesiometer, Somedic Sales AB, Sweden) were used for transient pointed mechno-cutaneous stimulation. This stimulation gives an impression, which primarily is perceived as tactile perception. The bending pressures were 0.07, 0.40, 0.45, 0.70, 1.10, 1.90, 2.50, 5.00, 8.00, 13.00, 24.00, 33.00, and 45.00 g. For these filaments, the degree of bending does not influence the exerted pressure. A Thermostat (Somedic Sales AB, Sweden) was used for thermal stimulation with two equally sized contact thermodes \((25 \times 50 \text{mm})\) built according to the Pelizzi principle (Kenshalo and Bergen, 1975). The thermodes were heated and cooled to two series of 16 or two series of 19 selected warm or cold surface temperatures, respectively: for warm 33, 36, 38, 38.5 and each 0.5 step up to \(50^\circ \text{C}\) and for cold 33, 28, 26, 25.5 and each 0.5 step down to \(10^\circ \text{C}\) (linear rise \((1.5^\circ \text{C/s})\) and fall \((0.5^\circ \text{C/s})\) from a baseline temperature of \(32^\circ \text{C}\)). Two switches could interrupt stimulation, one for the subject, and one for the experimenter.

2.3. Procedure

The same principle design was used during all experimental sessions. The perceived intensity was scaled by the method of magnitude estimation separately for tactile, cold or warm stimulation. Pain-unaffected thenar (ball of thumb) was always stimulated and scaled, alternately, with another body area that was either pain-affected (neuropathic pain and FMS patients) or pain-unaffected (all healthy participants, in neuropathic pain patients also contralateral homologous area to pain area). Thenar was selected contralateral to all body areas, except for the neuropathic pain patients' unaffected areas contralateral to their pain-affected area. Stimulus presentations were
always constructed from two random orders, one for thenar and one for the other body area; each other presentation selected from the one or the other random order. For every participant, the order of modality scaled was warmth, cold and touch; touch not tested for 48 healthy participants. In all, 109 psychophysical thenar functions for cold, 109 thenar functions for warmth, and 61 thenar functions for touch were determined and their individual constants used in the Master Scale transformations.

3. Results

3.1. Master Functions for perceived intensity of touch, cold and warmth at thenar

In the following, Master Functions of perceived intensity at thenar for the three modalities touch, cold and warmth are proposed. The three functions are based on empirical data obtained by the method of free-number magnitude estimation, Fig. 1.

3.2. Touch

In order to create a Master Function for perceived intensity of touch, the thenar magnitude estimates made by 21 neuropathic pain patients are utilized (painfree thenar located at contralateral side to the pain affected body areas). The reliability of the perceived intensity scales are high for all patients (average internal consistency is $r = 0.94$, range: 0.51–0.95; average stability is $r = 0.94$, range: 0.88–0.99; $n = 21$). Psychophysical power functions (Eq. (1)) for perceived intensity and bending pressure in gram fit well with individual exponents ranging from 0.2 to 1.2 ($n = 21$). The group thenar power function is shown in the left-hand diagram of Fig. 1, and it is here proposed as the Master Function (Eq. (2)) for perceived intensity of touch ($R_m$):

$$R_m = 1.65^{0.4}, \quad (9)$$

where $S$ stands for stimulation of thenar with bending pressure in gram.

3.3. Cold and warmth

In order to create a Master Function for perceived intensity of cold or of warmth, thenar magnitude estimates made by 48 healthy persons are utilized. The reliability of the perceived intensity scales are high for both cold and warmth in all the 48 persons, average internal consistency is $r = 0.74$ (range: 0.43–0.97) and $r = 0.84$ (range: 0.55–0.95), respectively. Power functions fit well to the 48 individual plots of perceived intensity of cold (Eq. (5)) and of warmth (Eq. (6)). For cold the individual exponents range from 0.3 to 2.9 and for warmth from 0.5 to 3.1. The group thenar power function for cold is shown in the middle diagram of Fig. 1, and it is here proposed as the Master Function (Eq. (5)) for perceived intensity of cold

$$R = 1.3(S_0 - S)^{1.1}, \quad (10)$$

where $S_0$ is 304 K or 31 °C depending on temperature scale. The group thenar power function for warmth is shown in the right-hand diagram of Fig. 1, and it is here proposed as the Master Function (Eq. (6)) for perceived intensity of warmth

$$R = 0.5(S - S_0)^{1.6}, \quad (11)$$

where $S_0$ is 304 K or 31 °C depending on temperature scale. The power-function exponents of 1.1 for cold and 1.6 for warmth coincide with exponents earlier published (e.g., Stevens, 1975).

3.4. Screening participants on scaling behavior

In total, 109 individual thenar functions were determined for cold or warmth and 61 thenar functions for touch. All patients’ and healthy persons’ thenar functions could be described as normal power functions. Originally, as a first step of screening perceptually competent individuals, we had planned to identify atypical persons with regard to scaling behavior in the magnitude estimation task at thenar such that these could be excluded from the group considered competent to scale perceived intensity. Since it turned out that all participants behaved the same in the magnitude.
estimation task for thenar, we conclude that all tested participants are able to scale perceived intensity of touch, cold and warmth.

As a second step of screening competent individuals, we planned to identify atypical persons with regard to magnitude-estimation scaling behavior at the homologous pain-affected areas contralateral to pain-affected areas. Such body areas were tested in the 21 neuropathic pain patients. Examples of individual psychophysical (power) functions for cold of 10 of these patients are shown in Fig. 2: five different thighs (upper row of five diagrams), three different knees (lower row, three diagrams to the left) and two groins (lower row, two diagrams to the right). It turned out that all the 21 neuropathic pain patients produced normal power functions at contralateral unaffected body areas, with a variation in the three constants referable to specific body areas. We, therefore, conclude that the 21 neuropathic pain patients behaved the same in the magnitude estimation task for various body areas as they and the 48 healthy participants did for perceived intensity of cold at thenar.

In a third step of screening perceptually competent individuals, the power functions for cold of unaffected

![Fig. 2. Interindividual variation in master scaled perceived intensity for cold at contralateral, pain-unaffected (thighs (n = 5), knees (n = 3), and groins (n = 2) in neuropathic pain patients.](image)

![Fig. 3. Interindividual comparison of master scaled perceived intensity for cold at pain-unaffected upper arm, knee, and foot, for healthy persons (upper three diagrams), neuropathic pain patients (middle three diagrams), and at corresponding pain-affected areas in the same neuropathic pain patients (lower three diagrams).](image)
body areas contralateral to pain-affected areas in the neuropathic pain patients are compared to power functions produced by healthy participants in corresponding body areas. For example, the perceived intensity of cold at pain-unaffected upper arm, knee or foot was scaled both by healthy participants (Fig. 3, upper row) and by neuropathic pain patients (Fig. 3, middle row). The patients also scaled the perceived intensity of cold in homologous pain affected upper arm, knee or foot (Fig. 3, lower row of diagrams). The master scaled perceived intensities showed normal power functions for these three unaffected body areas in healthy persons as well as in patients. Table 1 shows the constants of fitted power functions for perceived intensity of cold for upper arm (average \( n = 1.7 \), range: 0.9–3.9), for knee (average \( n = 1.5 \), range: 1.0–2.7) and for foot (average \( n = 1.4 \), range: 0.8–2.8) for tested pain-unaffected body areas. Thus, the exponent for the upper arm is larger than that for the knee which in turn is larger than the exponent for the foot. At thenar the average exponent is even lower, namely 1.1 (see Fig. 1, middle diagram).

However, the patients’ psychophysical functions for the pain-affected upper arm, knee or foot are not normal power functions. In comparison with the same patients’ normal power functions for unaffected body areas (upper arm, knee, foot), the pain affected areas show hypofunction for the upper arm, hypofunction for the knee and a disrupted function for the foot (possibly slight increase for nociceptive stimulation). Please note that the results for pain-affected areas are unique to these particular three patients and their nerve injuries and cannot be generalized as characteristic of specific body area. The strength of the master scaling procedure applied in the experiments is that master scaled perceived intensity can be compared on “calibrated” scales for singular individuals whether they are pain patients or healthy persons or whether the scales refer to pain-affected or pain-unaffected body areas.

### 3.5. Psychophysical functions for warmth before and after Master Scaling

The psychophysical functions for warmth obtained in three neuropathic pain patients are compared in Fig. 4, before and after master scaling perceived intensity (the three left and three right diagrams, respectively). Before the master scale transformation (Eq. (8)), individual scales of perceived intensity of warmth were assessed by free number magnitude estimation in each patient’s pain-affected area (each other temperature was presented at thenar). As a control, the experiment was repeated with stimulation, alternately, at the contralateral area and at thenar. Normal power functions were obtained at these two body sites. Fig. 4 shows the perceived intensity of warmth plotted against temperature in °C for the upper arm (top), palm of hand (middle) and stomach (bottom); the patient’s pain-affected site as open circles and contralateral area as filled circles. The results before (raw magnitude estimates) and after master scaling are compared (left vs. right diagrams, respectively). Notably, the master scaling has kept the relative warmth intensities invariant for pain-affected and contralateral areas but has changed the absolute warmth intensities between patients. These three pain patients were selected for illustration because they used a similar range of numbers in the free-number magnitude estimation task. Notably, they gave distinctly different power functions for identical sets of temperatures.

### Table 1

<table>
<thead>
<tr>
<th>Individual</th>
<th>Power function constants for Master Scaled perceived intensity for cold at pain-unaffected upper arm (( n = 10 ). knee (( n = 11 )) and foot (( n = 10 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual no.</td>
<td>Power function constants</td>
</tr>
<tr>
<td>1</td>
<td>Upper arm</td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>0.5</td>
</tr>
<tr>
<td>8</td>
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</tr>
<tr>
<td>9</td>
<td>0.6</td>
</tr>
<tr>
<td>10</td>
<td>0.8</td>
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<tr>
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</tr>
<tr>
<td>1</td>
<td>Knee</td>
</tr>
<tr>
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Range of \( S_0 = 303-298 \text{ K} \) (29.5–25°C).
at the pain-unaffected thenar although it was scaled, alternately, with target area.

The pair of curves displayed in each diagram to the left in Fig. 4 are not comparable within an individual if thenar had not been scaled, alternately, with the pain affected or contralateral body area (both areas were scaled within the same context of warmth intensities perceived at thenar; cf. Berglund et al., 2002). Moreover, if the thenar master function had not been used for master scaling each patient’s perceived intensity of warmth, these scales would not have been comparable. Since master scaling was applied, we can now conclude that the pain-unaffected stomach is more sensitive to warm temperatures than the pain-unaffected hand.

3.6. Identifying patients with atypical psychophysical functions in pain areas

Psychophysical functions for master scaled perceived intensity of cold and warmth from two different pain-affected body areas in one typical FMS patient are presented in Fig. 5. The psychophysical functions for warmth (right upper and lower diagrams) at the trapezius muscle and the lower back are quite similar and approximate normal power functions. However, for cold stimulation at the corresponding body areas (left upper and lower diagrams), the psychophysical functions are distinctly different and deviate from normal power functions. In the experiment with the 20 FMS patients, the age-matched controls produced close to normal power functions for cold in all body areas; this include 19 controls who scaled trapezius and 7 who scaled the lower back. In general, the typical FMS patient produces a better power function than the neuropathic-pain patient does when tested in pain-affected body areas. This applies for cold as well as for warmth. Among the tested FMS patients, two atypical cases were identified. This was made possible by determining individual psychophysical functions for every tested body area. The two atypical FMS patients both produced normal power functions at thenar but highly aberrant
functions for cold at trapezius, lower back and neck and for warmth at trapezius and lower back.

The fact that these two patients produced normal power functions at the far indicate that they were able to scale adequately perceived intensity with the method of magnitude estimation. The aberrant function for one of the atypical FMS patients is shown in Fig. 6. For cold and warmth in both pain areas, this patient does not discriminate perceived intensities well for the various temperatures. The reason for this is probably that nearly
all the innocuous and noxious temperatures were reported as painful. As a consequence, the main response strategy seems to be to give one high number for most temperatures. For warmth, the extremely high perceived-intensity values display this strategy. For thenar, this atypical FMS patient did neither report that the temperatures were painful nor give magnitude estimates outside the normal range of numbers for other patients. We conclude that this particular FMS patient is atypical for the group of FMS patients but is not a patient that is unable to scale perceived intensity.

3.7. Interindividual variation before and after Master Scaling

The coefficient of variation (CV) is a convenient statistics for exhibiting individual variation in a distribution. It is a ratio in which the standard deviation is expressed in proportion to the arithmetic mean. Fig. 7 shows the CV for perceived intensity before and after master scaling plotted as a function of cold temperatures. The two upper diagrams compare the CV obtained for all thenar and the two lower diagrams the CV obtained for all the 11 unaffected knees and the 10 unaffected feet tested in healthy and neuropathic pain patients.

The CV before and after Master Scaling of perceived intensity at pain-unaffected thenar is similar in size for the 68 healthy persons and 21 neuropathic pain patients ($N = 89$) as for the 20 FMS patients (Fig. 7, left and right upper diagrams). After master scaling, the CV for perceived intensity at thenar is on average 0.23 for the healthy group and 0.18 for the FMS patients. For the pain-unaffected knees and feet, the CV covaries with temperature such that it is 2-3 times as high for cold temperatures close to the neutral zone as for lower temperatures. The CV seems to be invariant for the temperatures in the nociceptive range (<20 °C). Compared to thenar, the CV for master scaled perceived intensity at the knee and the foot is twice as large (ca. 0.4 for the nociceptive range). This may be explained by a low sensibility at lower limbs compared to thenar.

The interindividual variation is considerably reduced after master scaling. In earlier experiments, the utilization of the interindividual differences in the master scale transformation makes the interindividual variation approximately equal to the intraindividual variation (for loudness, see e.g., Berglund and Nordin, 1990; Berglund and Preis, 1997). For the presently studied 109 participants, no intraindividual variation was possible to assess because of only two repetitions of the same stimulation for the same person. However, healthy persons’ CV for intraindividual variation, for cold and warm at thenar, after master scaling is of the same size (0.23) as the CV for intraindividual variation of loudness of pulse trains of rectangular sound bursts (ca. 0.27). This would mean that the master scaling of perceived intensity reduces the intraindividual variation to that of the intraindividual variation also for cold and warm. This result would be expected if the intraindividual variation is referable mainly to variation in the use of numbers in magnitude estimation.

4. Concluding remarks

In the master scale transformation, no physical measure of the target stimulus enters into the calculation. Thus, the master scale transformation requires no knowledge whatsoever of the target except for its empirical perceived intensity values. This is indeed the purpose of the master scaling procedure in clinical

Fig. 7. Interindividual variation in perceived intensity for cold before and after Master Scaling, at pain-unaffected thenar (upper two diagrams), at pain-unaffected knees (lower left diagram), and at pain-unaffected feet (lower right diagram).
Spinal cord injury pain

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Abstract

Awareness that SCI pain is common emerged during the past decade. However, there are a number of unresolved issues. There is a need for variety of experimental models to reflect diversity of SCI pains. Current classification is not as user-friendly as it should be. More attention should be given to a condition of the spinal cord below and above the SCI lesion. A consensus for what is an optimal SCI functional assessment for patients with sensory complaints and pain should be developed. Further extensive SCI pain research is needed prior to spinal cord regeneration trials in order to be able to cope with a potential for newly developed pains that may appear during incomplete spinal cord regeneration attempts.

Keywords: Spinal cord injury; Pain; Central pain; Spinal cord; Spinal cord regeneration

One wonders why a larger impact on the understanding and treatment of spinal cord injury (SCI) pain has not been made during the last decade. Actually, contributions have been made, but the root cause of pain is still unknown and the efficacy of treatment in the SCI patient is not predictable. This is occurring as the Decade of the Brain and health politicians' promises of curing neurologic diseases such as Parkinson's disease has passed and left us with a need for new promises and big name actions. One thing has definitely happened that may help the SCI pain field move forward into this and the next decade; awareness that SCI pain exists, is common, and may be as devastating as other SCI consequences (Bonica, 1991; Yezierski and Burchiel, 2001). This is a prerequisite for any expansion of the field. Another important issue that has evolved is a need for classification (Beric, 1997; Siddall et al., 1997). In order to further this field types of pain need to be categorized, their frequency and how to interpret the results of pain treatment in light of different types of SCI pain. As an additional consequence of SCI pain awareness there are now a number of experimental models that were specifically developed to tackle this problem (Hao et al., 1991; Vierck and Light, 1999; Yezierski et al., 1998).

A breakthrough in SCI pain management can happen in either two ways: through serendipity or as a consequence of systematic contributions and incremental understanding of the biological consequences of SCI and the mechanism of pain in general. More specifically, understanding neurogenic and central pain. However, the problem is that not a lot is known about SCI and even less is known regarding central pain.

The field of SCI pain is intricately connected to both the SCI field and pain research, but to such an extent that both clinical and experimental researchers need to respect this complexity. SCI leads to a variety of different clinical presentations, from complete, incomplete, with or without sacral sparing, without sacral sparing, more sensorimotor, more motor involvement, mainly upper motor neuron (UMN) features, combined UMN and lower motor neuron (LMN) features, etc. In addition, cauda equina injury and pain is a separate root/peripheral nerve problem. Most of these different presentations can be assessed by American Spinal Injury Association (ASIA) standard exam, although clinical researchers studying SCI pain have not fully taken this approach. It is less clear how basic researchers are handling these complexities. To complicate things even more...