The Erasmus MC modifications to the (revised) Nottingham Sensory Assessment: a reliable somatosensory assessment measure for patients with intracranial disorders

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Objective: To investigate the intra-rater and inter-rater reliability of the Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA).

Subjects: A consecutive sample of 18 inpatients, with a mean age of 57.7 years, diagnosed with an intracranial disorder and referred for physiotherapy.

Setting: The inpatient neurology and neurosurgery wards of a university hospital.

Design: Through discussions between four experienced neurophysiotherapists, the testing procedures of the revised Nottingham Sensory Assessment were further standardized. Subsequently, the intra-rater and inter-rater reliabilities of the EmNSA were investigated.

Results: The intra-rater reliability of the tactile sensations, sharp–blunt discrimination and the proprioception items of the EmNSA were generally good to excellent for both raters with a range of weighted kappa coefficients between 0.58 and 1.00. Likewise the inter-rater reliabilities of these items were predominantly good to excellent with a range of weighted kappa coefficients between 0.46 and 1.00. An exception was the two-point discrimination that had a poor to good reliability, with the range for intra-rater reliability of 0.11–0.63 and for inter-rater reliability – 0.10–0.66.

Conclusion: The EmNSA is a reliable screening tool to evaluate primary somatosensory impairments in neurological and neurosurgical inpatients with intracranial disorders. Further research is necessary to consolidate these results and establish the validity and responsiveness of the Erasmus MC modifications to the NSA.

Introduction

A reliable clinically useful screening tool to measure somatosensory impairments for patients with intracranial disorders has to date not been developed. This is remarkable considering the important role of the somatosensory system in motor control1–3 and the high prevalence (35–60%) of somatosensory deficits after stroke,4 especially since somatosensory deficits have been associated with less favourable functional outcomes.5–9 Such results are not totally unexpected as the somatosensory system plays an important part in motor control. Cutaneous reflexes, for example, assist in motor co-ordination between arms and legs during
walking and, along with the proprioceptive reflexes, contribute to the prevention of falls during human locomotion.\textsuperscript{1,2} In the absence of vision, somatosensory inputs to the brain provide knowledge of where our limbs and body are in space.\textsuperscript{3}

A reliable somatosensory assessment measure also provides a baseline at the beginning of the rehabilitation process, so enabling any alterations in sensory state to be monitored over time. With the recent indications that sensory retraining programmes with stroke patients are effective\textsuperscript{10–12} knowledge of somatosensory impairment can provide useful information to predict functional outcome and may be helpful in selecting appropriate treatment goals.

Literature searches on the subject found three screening tools: the Nottingham Sensory Assessment (NSA),\textsuperscript{13} the revised Nottingham study (rNSA)\textsuperscript{14} and the Rivermead Assessment of Somatosensory Performance (RASP).\textsuperscript{15} The reliability of the RASP was not conclusive (see Discussion) and the reliability of the rNSA was not consistently good for all items. However, in contrast to the RASP, no special expensive equipment is required for the administration of the rNSA. Therefore, the aim of this study was to improve the reliability of the rNSA by providing modifications and further standardization of the testing procedures.

**Methods**

All the modifications to the chosen test items of the rNSA were decided through regular discussions between four experienced neurophysiotherapists working in the acute care setting at the Erasmus MC, University Medical Center in Rotterdam. From the original items of the rNSA (light touch, pressure, pinprick, temperature, kinaesthetic sense and two-point discrimination) the following changes were made. The temperature test was excluded according to the recommendations in the revised Nottingham study. A sharp–blunt discrimination was added to assess pain sensation.\textsuperscript{16} The pinprick test remained as an item to assess tactile sensation. The scoring of the two-point discrimination test item was modified in accordance with the assessment recommendations of the American Society for Surgery of the Hand\textsuperscript{17} and the kinaesthetic sensation item (proprioception) was further standardized. Details of these modifications are incorporated in the guidelines in Appendix 1, with Appendix 2 providing additional standardizations for the defined points of contact used with the tactile sensation items. Appendix 3 contains the specific standardizations for the proprioception item. The general guidelines and score sheet for the EmNSA (Erasmus MC modifications to the (revised) Nottingham Sensory Assessment) were updated to include additional standardizations and a uniform scoring system, (see Appendices 1 and 4).

**The assessment**

This study was approved by the hospital medical ethics committee and took place within a limited two-month period (April–May 2003). All current inpatients, along with all new admissions to the neurology and neurosurgery wards of the Erasmus MC and referred for physiotherapy, were screened for eligibility for inclusion in the study. Inclusion criteria were: an intracranial disorder, diagnosed by a neurologist or neurosurgeon and by neuroimaging studies, at least 18 years of age. Excluded from the study were patients with a peripheral neurological disorder, a disorder at the level of the spinal cord, Parkinson's disease or other hypokinetic rigid syndromes, multiple sclerosis, or a severely impaired cognitive state. To exclude patients with considerable cognitive impairments, the observers administered the Mini-Mental State Examination (MMSE).\textsuperscript{18} Some cognitive impairment was allowed, therefore, a cut-off point was introduced. A score of at least 15 points was required to take part in the study. Prior to enrolling in the study a full explanation of the procedure was given to the patient by an examiner. Informed consent was then obtained.

Two physiotherapists acted as examiners for the study. One examiner had over 20 years’ experience working with patients with intracranial disorders, the other physiotherapist one year. Both physiotherapists continued to have a clinical caseload throughout the period of this study so helping to minimize the recall of the results for the intra-rater reliability.

To assess the intra-rater reliability each examiner tested all the patients on two occasions. To
minimize any recall bias there was an interval of at least 24 h between the initial and repeat test occasions. To assess the inter-rater reliability, the two examiners assessed each patient on the same day, with an interval of at least 1 h, but not more than 2 h. Throughout the study period the examiners were blind to each other’s results.

Descriptive statistics were carried out on SPSS version 10.1 for Windows and Intercooled Stata 5.0. SPSS was used to calculate the weighted kappa coefficients.

Results

Twenty-one patients were eligible for the study, however three patients were excluded due to a MMSE score of less than 15 points. Therefore, the final study sample consisted of 18 inpatients (nine men, nine women) with neurological (n = 14) or neurosurgical (n = 4) disorders. Two patients were assessed on both sides. The mean age was 57.7 years (range 20–84) and the mean number of days since admission was 14.9 days (range 4–92). Diagnostic details are described in Table 1.

Five patients (28%) achieved a normal score, for all the test items. Some degree of sensory impairment was seen in six patients (33%). Seven patients (39%) had severe sensory loss; they scored 0 or 1 on five or more test items (see Table 2).

Intra-rater reliability

According to the Fleiss categories for Cohen’s kappa coefficient,19 the intra-rater reliability of the Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA) for both raters is generally good to excellent (Table 3).

Only two of the weighted kappa coefficients, of the 84 calculated, represented a poor agreement (both for two-point discrimination). Of the remaining 82 results, only two represented a fair agreement and 11 a good agreement. Thus 81% of the weighted kappa coefficients (68 values) represented an excellent agreement. Rater A had slightly less favourable results than rater B.

Inter-rater reliability

The inter-rater reliability of the Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA) is predominantly good to excellent (Table 4). The weighted kappa coefficient of the two-point discrimination at the fingertip had a negative score. At the thenar eminence the reliability of the two-point discrimination was good.

Only one of the weighted kappa coefficients, of the 52 calculated, represented a poor agreement (two-point discrimination). Of the remaining 51 results only two represented a fair agreement and nine a good agreement. Thus 77% of the weighted kappa coefficients (40 values) represented an excellent agreement.

Discussion

This study has developed standardized modifications to the revised Nottingham Sensory Assessment for use with patients diagnosed with an intracranial disorder. The reproducibility of the chosen items included in the EmNSA is now predominantly good to excellent. The original studies (including only stroke patients) were unable to reach such high levels of reliability. The improved intra-rater and inter-rater reliability is most likely due to the additional standardized modifications made to the guidelines of the assessment measure. Feedback from the examiners and observers confirmed that the EmNSA is a clinically feasible assessment measure and easy to administer. However, it still requires approximately 10–15 min to administer. This amount of time could possibly be reduced if a hierarchy were established for the test items and the points of contact.

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**Table 1** Demographic details of the study sample (n = 18)

<table>
<thead>
<tr>
<th></th>
<th>Left-sided</th>
<th>Right-sided</th>
<th>Bilateral</th>
<th>Total</th>
<th>Sets of data</th>
</tr>
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<td>6</td>
<td>2a</td>
<td>12</td>
<td>14</td>
</tr>
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<td>Cerebral tumour</td>
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<td>Traumatic brain injury</td>
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<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Both sides assessed.
SAH, subarachnoid haemorrhage.

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Table 2  Data set scores for the upper and lower extremities for each test item to summarize the spread of somatosensory impairments in the study sample

<table>
<thead>
<tr>
<th>Test/data set</th>
<th>Light touch</th>
<th>Pressure</th>
<th>Pinprick</th>
<th>Sharp–blunt discrimination</th>
<th>Proprioception</th>
<th>Somatosensory impairment</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>UE LE</td>
<td>UE LE</td>
<td>UE LE</td>
<td>UE LE</td>
<td>UE LE</td>
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<tr>
<td>1</td>
<td>2 1</td>
<td>2 2</td>
<td>2 2</td>
<td>2 2</td>
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<tr>
<td>2</td>
<td>2 1</td>
<td>2 2</td>
<td>2 2</td>
<td>2 2</td>
<td>2 2</td>
<td>slight</td>
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<tr>
<td>3</td>
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<td>2 1</td>
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<td>5</td>
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<td>2 2</td>
<td>2 2</td>
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<td>7</td>
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<td>2 1</td>
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<tr>
<td>8</td>
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<td>0 1</td>
<td>0 1</td>
<td>0 1</td>
<td>0 1</td>
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<tr>
<td>9</td>
<td>N/T(p) 0</td>
<td>N/T(p) 0</td>
<td>N/T(p) 0</td>
<td>N/T(p) 0</td>
<td>N/T(p) 1</td>
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<td>2 1</td>
<td>2 1</td>
<td>2 2</td>
<td>2 1</td>
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<td>13</td>
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<td>16</td>
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<td>17</td>
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<td>18</td>
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<td>2 2</td>
<td>2 2</td>
<td>2 2</td>
<td>normal</td>
</tr>
</tbody>
</table>

UE, upper extremity; LE, lower extremity; N/T(p), not tested – arm in plaster cast; N/T(c), not testable, due to cognitive impairments; N/A, not applicable, sharp–blunt discrimination was not assessed due to a score of 0 for the light touch, pressure or pinprick items.

0, total absence of the test item throughout the upper or lower extremity; 1, parts of the upper or lower extremity tested were impaired; 2, totally normal for that test item for the entire upper or lower extremity.

Results taken from the first assessment of each patient by rater B.

*The two-point discrimination results are excluded from this table due to the poor reliability of the testing procedure (details in the Results section).
Table 3  Weighted kappa values for the intra-rater reliability of rater A and rater B on the EmNSA

<table>
<thead>
<tr>
<th>Rater:</th>
<th>Light touch</th>
<th>Pressure</th>
<th>Pinprick</th>
<th>Sharp–blunt discrimination</th>
<th>Proprioception</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Fingers</td>
<td>0.62</td>
<td>1.00</td>
<td>0.87</td>
<td>0.87</td>
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<tr>
<td>Hand</td>
<td>0.71</td>
<td>0.87</td>
<td>0.63</td>
<td>0.84</td>
<td>0.87</td>
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<tr>
<td>Forearm</td>
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<td>0.87</td>
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<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Upper arm</td>
<td>0.84</td>
<td>0.71</td>
<td>0.84</td>
<td>0.71</td>
<td>1.00</td>
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<tr>
<td>Upper extremity</td>
<td>0.83</td>
<td>0.94</td>
<td>0.89</td>
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<tr>
<td>Toes</td>
<td>0.86</td>
<td>0.64</td>
<td>0.75</td>
<td>0.84</td>
<td>0.79</td>
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<tr>
<td>Foot</td>
<td>0.76</td>
<td>0.92</td>
<td>0.92</td>
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<td>1.00</td>
</tr>
<tr>
<td>Leg</td>
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<tr>
<td>Thigh</td>
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<td>1.00</td>
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<tr>
<td>Lower extremity</td>
<td>0.77</td>
<td>0.78</td>
<td>0.83</td>
<td>0.91</td>
<td>0.87</td>
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</tbody>
</table>

Two-point discrimination

<table>
<thead>
<tr>
<th>Rater:</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingertips</td>
<td>0.63</td>
<td>0.11</td>
</tr>
<tr>
<td>Thenar eminence</td>
<td>0.28</td>
<td>0.58</td>
</tr>
</tbody>
</table>

*Kappa values could not be calculated because the contingency table had a row with zero elements.

Fleiss categories for Cohen's kappa: 0.00–0.39 poor agreement; 0.40–0.59 fair agreement; 0.60–0.74 good agreement; 0.75–1.00 excellent agreement.19
Although only 18 patients were involved in this study (resulting in 20 sets of data) this number does meet the minimal size requirements for a sample, as suggested by Cicchetti.\textsuperscript{20} When using the kappa statistic the sample size is calculated in relation to the number of categories in the scoring system. In reliability studies it has to be taken into account that the (weighted) kappa statistic is influenced by the selection of subjects over which it is defined (i.e. the kappa statistic is dependent on the distribution across all the categories). If the subjects are highly variable then the kappa statistic tends to be high, whereas for a more homogeneous group of subjects it will be lower.\textsuperscript{21} This implies that the disorder not the disease (i.e. the level of somatosensory impairments in the research population) has consequences for the kappa statistic.

Another problem of the kappa statistic is that when one of the possible scoring categories is not chosen, in other words the contingency table has a row or column with all zero elements, the kappa statistic cannot be calculated. This occurred in three out of the 136 results in our study. Despite some drawbacks, the weighted kappa remains an appropriate statistical method of analysis of ordinal data for agreement within and between raters.

The use of parametric statistical tests for non-parametric data should only be used with caution. In the RASP study the use of the Pearson correlation coefficient could lead to false-positive results (exaggerated high coefficient values) as association is examined, not agreement.\textsuperscript{21,22} Likewise, the use of Bland and Altman plots may also be inappropriate, as although they consider rater agreement, they are based on parametric principles.\textsuperscript{23}

In our study the research population included all eligible patients with intracranial disorders. Over half of these were stroke patients and of the total sample, 72% were found to have some degree of somatosensory impairments (compared with 60% expected in a stroke population).\textsuperscript{2} Despite the high percentage of patients with one or more sensory impairments, the overall level of sensory impairments in our subjects was low. This is a disadvantage of our study population. Our research population probably differs at this point from a population of stroke patients, the level of somatosensory impairments in stroke patients should be overall higher. Therefore, to make reliability studies more comparable the distribution across the categories should be published, especially with small sample sizes, which require more variability in data. We included all eligible patients with

\begin{table}[h]
\centering
\caption{Weighted kappa values for the inter-rater reliability on the EmNSA}
\begin{tabular}{|l|c|c|c|c|c|}
\hline
 & Light touch & Pressure & Pinprick & Sharp–blunt discrimination & Proprioception \\
\hline
Fingers & 0.89 & 1.00 & 0.87 & 1.00 & Fingers & 0.71 \\
Hand & 0.87 & 1.00 & 0.76 & 0.84 & Wrist & 0.63 \\
Forearm & 0.87 & 1.00 & 1.00 & 0.84 & Elbow & 1.00 \\
Upper arm & 0.71 & 0.84 & 1.00 & 1.00 & Shoulder & 0.46 \\
Upper extremity & 0.90 & 1.00 & 0.88 & 0.86 & Upper extremity & 0.74 \\
Toes & 0.86 & 0.83 & 0.90 & 0.53 & Toes & 0.69 \\
Foot & 0.85 & 0.92 & 0.90 & 0.81 & Ankle & \textsuperscript{a} \\
Leg & 0.83 & 0.83 & 0.79 & 0.90 & Knee & 1.00 \\
Thigh & 0.89 & 0.90 & 0.76 & 0.81 & Hip & 1.00 \\
Lower extremity & 0.81 & 0.83 & 0.88 & 0.70 & Lower extremity & 0.66 \\
\hline
\textbf{Two-point discrimination} & & & & & \\
Fingertips & \textemdash & 0.10 & & & \\
Thenar eminence & & 0.66 & & & \\
\hline
\end{tabular}
\end{table}

\textsuperscript{a}Kappa values could not be calculated because the contingency table had a row with zero elements.

Fleiss categories for Cohen’s kappa: 0.00–0.39 poor agreement; 0.40–0.59 fair agreement; 0.60–0.74 good agreement; 0.75–1.00 excellent agreement.\textsuperscript{19}
Clinical messages

- The modifications made in the Erasmus MC modifications to the Nottingham Sensory Assessment (EmNSA) have improved the reproducibility of the majority of the test items such that they now have predominantly good to excellent inter-rater and intra-rater reliability.
- Two-point discrimination remains an unreliable test item.
- The EmNSA is an inexpensive and easy assessment measure to administer as a screening tool in routine clinical practice.

Intracranial disorders because this is an exact copy of our clinical situation. We wanted the assessment of somatosensory impairments to be reliable and clinically useful not only in stroke patients but for most patients with intracranial lesions admitted to the neurology and neurosurgery wards. Hence the inclusion of patients with mild cognitive disorders.

Although the kappa coefficients for proprioception have improved in this study, they have not reached such high levels of reliability as the tactile sensations. Two-point discrimination remains a test item that is difficult to reproduce and is therefore not included on the definitive version of the EmNSA score sheet.

From the intra-rater reliability results it is evident that whilst both physiotherapists achieved good to excellent levels of agreement those achieved by the more experienced physiotherapist (rater B) were generally higher. This may suggest that clinical experience positively influenced the intra-rater reliability. Both the intra-rater reliability and the inter-rater reliability of the upper extremity have higher levels of agreement than those of the lower extremity. This is consistent with the results of the revised NSA study and may relate to the larger representation of the arm in the brain (Penfield’s sensory homunculus).

Conclusion

The EmNSA is a reliable, standardized assessment measure, which is easy, inexpensive and relatively quick to administer. Therefore, it is a useful screening tool in the clinical setting for the assessment of primary somatosensory impairments in acute patients with an intracranial disorder. With such promising results from this preliminary study, further work is now planned with a larger, diverse population. Such research should support these conclusions and aim to establish the validity and responsiveness of the EmNSA modifications to the revised Nottingham Sensory Assessment in the acute care setting.

Acknowledgements

This project was undertaken in conjunction with the Hogeschool Rotterdam, with Diane Breedijk (lecturer in physiotherapy) providing valuable advice throughout the study.

We would like to thank Sylvia Gorter and Marieke Sizoo for acting as examiners and along with four of the authors participating in the initial discussions. We would also like to thank Elizabeth Carr and Denise Coleman for their valuable comments on this article prior to its submission.

Copies of the EmNSA guidelines can be obtained from the authors in English and Dutch.

References

7. Ken C, Leo MA, Soderberg GL. Relationship between perception of joint position sense and limb...

**Appendix 1 – Guidelines for the Erasmus MC Modifications to the (revised) Nottingham Sensory Assessment (EmNSA)**

**General instructions**

The patient, suitably undressed, lies on a bed in the supine position, with the forearms in supination. The patient is asked to close their eyes whilst the actual testing is in progress. Each test item is explained in turn to the patient and, if necessary, demonstrated on the unaffected side. Testing should begin distally (i.e. fingers, toes). As a screening tool the affected side only is tested. However for more detailed information both sides can be tested. Each body section is tested once, in any order, at the three defined points of contact as described in Appendix 2. No more than 2–5 s should elapse between the stimuli of a specific test item.

A reminder of the defined points of contact can be found on the scoresheet.

**Tactile sensation (light touch, pressure and pinprick)**

For each test item, the skin is stimulated three times, at each location, in a random order, using the defined points of contact. The patient indicates verbally or non-verbally\(^a\) whenever he or she feels the test stimulus.

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\(^a\) Patient and physiotherapist agree, in advance, the most suitable manner in which the test sensation is indicated, e.g. by specific hand movements. whenever he feels the test stimulus.
Scoring criteria for light touch, pressure and pinprick.

0 Absent Patient fails to identify the test sensation on all three occasions.
1 Impaired Patient identifies the test sensation on only one or two occasions.
2 Normal Patient identifies the test sensation on all three occasions.

With light touch, if a score of 2 is assigned for all of a limb, then automatically assign a score of 2 for all the pressure and pinprick test items.

- **Light touch** Touch the skin, at the defined points of contact, lightly with a cotton wool ball.
- **Pressure** Apply pressure to the skin, using the index finger, at the defined points of contact, sufficient enough to just deform the skin contour.
- **Pinprick** Prick the skin using a cocktail stick, at the defined points of contact, sufficient enough to just deform the skin contour.

**Sharp–blunt discrimination**
Not tested if score 0 or 1 on tactile sensations. Stimulate the skin six times at each location, in a random order, three times with a cocktail stick and three times with the index finger, using the defined points of contact.

The patient must verbally describe or non-verbally indicate the test sensation as sharp or blunt.

Scoring criteria for sharp-blunt discrimination

0 Absent Patient fails to correctly describe/indicate the test sensation on all six occasions.
1 Impaired Patient correctly describes/indicates the test sensation, but on less than six occasions.
2 Normal Patient correctly describes/indicates the test sensation on all six occasions.

**Two-point discrimination**
Only test two-point discrimination if the patient has been assigned normal scores for all light touch, pressure and pinprick test items of the upper limb.

Set dividers at decreasing intervals. Apply the two points simultaneously to the skin of the index finger and then to the thenar eminence for approximately 0.5 s. Ask the patient to indicate if one or two points are felt. Record the last interval at which two points are felt.

Recommended starting intervals are for the thumb 10 mm and index finger 20 mm.

Scoring

0 Absent Patient is not able to detect two points.
1 Impaired Patient detects two points with an interval of 10 mm on the fingertip and 20 mm on the thenar eminence.
2 Normal Patient detects two points with an interval of 5 mm on the finger tip, and 12 mm on the thenar eminence.

**Proprioception**
Specified passive movements are tested in only one joint at a time. The starting positions, specific hand grips for the physiotherapist to use, along with the directions of the movement to be tested are described in Appendix 3. The large joints (hip and knee, shoulder and elbow) are moved through approximately a quarter of their total range of motion (ROM). The other joints (wrist and fingers, ankle and toes) are
moved throughout the full available range of movement. To demonstrate the procedure, three practice movements are allowed (with the patient’s eyes open.) Each joint is then moved three times. The patient is asked, using specific questions, to indicate verbally or non-verbally the direction of the movement taking place. If the patient is incapable of doing this, he is then asked to identify (verbally or non-verbally) when movement is taking place.

0 Absent Patient does not detect the movement taking place.
1 Impaired Patient detects the movement taking place but the direction is not correct on all three occasions.
2 Normal Patient correctly detects the direction of the movement taking place on all three occasions.

Appendix 2 – The Erasmus MC Modifications to the (revised) Nottingham Sensory Assessment

Defined points of contact for stimulating the light touch, pressure, pinprick and sharp-blunt sensations

A Fingers:
1) Distal phalanx 5th digit, palmar aspect
2) Distal phalanx 3rd digit, palmar aspect
3) Distal phalanx 1st digit, palmar aspect

B Hand
1) Second metacarpal, distal palmar aspect
2) Fifth metacarpal, distal palmar aspect
3) Centre of the thenar eminence

C Forearm
1) Ulnar styloid, anterior aspect
2) Centre of the forearm, anterior aspect
3) 2 cm distal to the elbow joint line, anterolateral aspect

D Arm:
1) 2 cm proximal to the elbow joint, anteromedial aspect
2) Centre of anterior aspect of the humerus
3) 2 cm distal to the acromion, lateral aspect

E Toes
1) Distal phalanx, 5th digit, plantar aspect
2) Distal phalanx, 3rd digit, plantar aspect
3) Distal phalanx, 1st digit, plantar aspect

F Foot
1) Base of 5th metatarsal bone, dorsal aspect
2) Second metatarsal, dorsal aspect
3) Centre of midtarsal line, dorsal aspect
G Leg
1) Medial malleolus, medial aspect
2) Centre of the anterior border of the tibia
3) Fibular head, lateral aspect

H Thigh
1) Medial femoral epicondyle, medial aspect
2) Centre of line of femur, anterior aspect
3) Greater trochanter

A reminder of these defined points of contact are represented diagramatically on the score sheet.

Appendix 3 – Specific starting positions, movements and hand grips for testing proprioception

Starting position
Unless otherwise stated, the patient remains in supine lying with the forearm in supination. The large joints (hip and knee, shoulder and elbow) are moved through approximately a quarter of their total range of motion (ROM). The other joints (wrist and fingers, ankle and toes) are moved throughout the full available range of movement.

Fingers
Movement: flexion and extension of the distal phalanx of the thumb.
Ask the patient: ’Is your thumb being bent or straightened?’

Hand grips
Distal (moving) hand: place the thumb laterally and the index finger medially on the distal phalanx of the thumb.
Proximal (fixing) hand: fix the proximal phalanx between thumb and index finger.

Wrist
Movement: flexion and extension of the wrist. Place the elbow in a starting position 150°–160° extension.
Ask the patient: ’Is your hand moving upwards or downwards?’

Hand grips
Distal (moving) hand: place the thumb on the lateral aspect and the index finger on the medial aspect of the hand.
Proximal (fixing) hand: fix the distal end of the forearm.

Elbow
Movement: flexion and extension of the elbow. Place the elbow in a starting position of 90° flexion.
Ask the patient: ’Is your elbow being bent or straightened?’

Hand grips
Distal (moving) hand: Grasp the distal end of the forearm, placing the thumb anteriorly and the fingers posteriorly.
Proximal (fixing) hand: Fix the distal end of the humerus
Shoulder
Movement: abduction and adduction of the shoulder. Place the elbow in 90° flexion, and lift the arm sufficient to allow the movements to occur. Ask the patient 'is your arm moving towards you or away from you?'

Hand grips
Distal (guiding) hand: grasp the distal end of the forearm with the thumb anteriorly and the fingers posteriorly.
Proximal (guiding) hand: grasp the flexed elbow in a cupped manner.

Toes
Movement: flexion and extension of the first metatarsophalangeal joint. Ask the patient: 'Is your toe moving upwards or moving downwards?'

Hand grips
Distal (moving) hand: place the thumb lateral and the index finger medial on the distal phalanx of the great toe.
Proximal (fixing) hand: fix the first metatarsal bone, just proximal to the metatarsophalangeal joint with the thumb lateral and the index medial.

Ankle
Movement: flexion and extension of the ankle joint. Ask the patient: 'Is your foot moving upwards or moving downwards?'

Hand grips
Distal (moving) hand: grasp the foot with thumb placed on the lateral margin of the foot and fingers on the medial margin of the foot.
Proximal (fixing) hand: fix the distal end of the tibia and fibula.

Knee
Movement: flexion and extension of the knee, with the hip joint in 90° flexion. Ask the patient: 'Is your knee being bent or straightened?'

Hand grips
Distal (moving) hand: grasp the calcaneus with the thumb medially and the fingers cupped inferiorly. The foot should be supported by the lower forearm.
Proximal (fixing) hand: grasp the distal end of the femur, with the thumb laterally and the fingers medially.

Hip
Movement: flexion and extension of the hip joint, starting with the hip in 90° flexion. Ask the patient: Is your thigh moving towards you or away from you?'

Hand grips
Distal (guiding) hand: grasp the calcaneus with the thumb medially and the fingers cupped inferiorly. The foot should be supported by the lower forearm.
Proximal (moving) hand: grasp the distal end of the femur and with the thumb laterally and the fingers medially. Maintain knee position accurately as you flex the hip.
Appendix 4 – EmNSA score sheet

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LT = light touch  PR = Pressure  PP = pinprick  SB = sharp-blunt discrimination
UE = upper extremity  LE = lower extremity
0 = absent  1 = impaired  2 = normal

Full description of points of contact available in appendix 2