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Shape-texture-identification—STI—A test for tactile gnosis: Concurrent validity of STI^2

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ABSTRACT

Study Design: Cross-sectional study.
Introduction: The shape-texture-identification (STI) test (Össur Nordic AB, Sweden) is used to evaluate one aspect of tactile gnosis in nerve disorders, and it has proven good methodological properties.
Purpose of the Study: A new version of the STI test was recently introduced—STI^2 (www.sensory-test.com). The purpose of this study was to test the concurrent validity in STI^2.
Methods: Using a cross-sectional design, this methodological study compared STI^2 to the original version based on 2 cohorts; 1 including 20 persons (1 affected finger and corresponding finger on in opposite hand) with affected sensibility after hand injuries and 1 healthy group including 20 persons (digits II and V in both hands). The agreement between the 2 versions of the instrument was calculated statistically by a percentage comparison of the test results and weighted kappa.
Results: The 112 tested fingers showed a complete agreement, or 1-point accepted deviation, between the 2 tests in 92% with weighted kappa of 0.74 and 95% confidence interval of 0.63-0.89. The result showed that there is no significant deviation between the 2 versions of the test.
Discussion: The use of standardizes and evidence based assessment tools in clinical practice is paramount for a patient centered healthcare. Previous research has shown good psychometric proprties in the STI-test. This study contributes to the scientific evidence of the instrument.
Conclusion: As the new STI^2 proved good agreement within the accepted deviation, we conclude that there is evidence to use the new STI^2 test in assessment of tactile gnosis.

Introduction

The sense of touch is a key factor in hand function,[1] and specific tactile information from the hand, combined with the dynamic processing of the brain, has made the human hand a sophisticated instrument with an enormous capacity to perceive, execute, and express in the explorative act of touch.[2] A functioning sense of touch creates a base for the use of the hands, and such touch is a vital part of activity—that is a basic driving force in humans.[3] Tactile gnosis, a composite function that depends on mechanisms in the peripheral and central nervous systems, was defined by Moberg[4] as "the complex sensibility that gives the grip sight."

Four major modalities of somatic sensibility can be defined: touch, proprioception, nociception, and temperature sense.[5] A hierarchy of touch functions can also be identified; When detection of touch is present, the next level is localization and the capacity to discriminate between 1 or 2 points on the skin that are touched, which is an aspect of discriminative touch; basic tactile gnosis. To resolve shape, form, and texture required for identifying objects, is the third level, a more refined tactile gnosis.[6] The highest level of tactile gnosis is the ability to pick up, hold, and manipulate small objects through touch and without vision[4] or the skin in concert with muscles, joints, and the brain.[2]

Once the touch threshold, equivalent to some protective sensibility at fingertip level, is established with Semmes-Weinstein monofilaments,[7] it is time to assess tactile gnosis. The original shape-texture-identification (STI) test was presented on 1998[8] and is today often used for assessment of tactile gnosis as a complement to the 2-point discrimination (2PD) test. However, due to methodological problems with 2PD, the STI test, which is based on active

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touch and has shown good psychometric properties,[8-13] is often the test of choice for this purpose today.

In clinical assessment recommendation from the American Society of Hand Therapist, the STI test is recommended for patients with nerve repair in addition to measures of touch thresholds.[14]

It is essential that the assessment instruments that are used in hand rehabilitation meet with psychometric requirements for a standardized test.[15] The assessments should also conform with the patient's opinion about the function, be responsive to changes over time, and preferably predict the long-term future development of the function.[16] Moreover, a good test should be comprehensive and easy to perform in a standardized way, not tiring or painful for the patient or too time consuming. The optimal tactile gnosis test after nerve injuries should also be applicable to both median and ulnar nerve injuries.[17] The original STI test meets with these requirements. A new version of the STI test—STI^2—has recently been introduced (www.sensory-test.com). The purpose of the study was to assess the agreement between the STI^2 and the original STI with the hypothesis that STI^2 provides the same result as the original.

Methods

Subjects

This cross-sectional study recruited subjects from 2 cohorts assessed with the original and new versions of the STI test. The 2 groups consisted of 1 group with patients with sensory-affected hands and a group of healthy subjects (Table 1). In accordance with COnsensus-based Standards for the selection of health Measurement INstruments recommendations, a sample size of 40 individuals (120 tested fingers) would ensure a good power.[18]

The inclusion criterion for the patient group was subjectively experienced sensory impairment with the ability to feel at least the #4.31 of Semmes-Weinstein monofilament.[7] The exclusion criteria were cognitive impairments or low knowledge of the Swedish language, which could affect the ability to understand the instructions about the test or the purpose of the study. In the healthy test group, prior or present sensibility impairment was an exclusion criterion.

The patient group was consecutively selected from patients who met the inclusion criteria at the Rehabilitation Unit at the Department of Hand Surgery in Malmö, during a period of 2 weeks. The patients came to the clinic for their regular treatment, and the therapist asked if they wanted to participate in the study. The test was performed by 2 of the authors (PL and JPE), and the result of the test was communicated back to the treating therapist to decide if the result would have significance for the patient's continued rehabilitation. A convenience selection determined the healthy group. Students in the occupational therapy program at Lund University were asked either by electronic mail or verbally.

The study was conducted according to the declaration of Helsinki. All participants gave written consent.

The concept of STI test and test procedure

STI test is a pure sensory test—the ability to resolve shape, form, and texture required for identifying objects. The STI test also forms part of the test battery in the model instrument for peripheral nerve repair, Rosen score.[11] Assessment using the STI test is performed in accordance with a standardized test procedure (Fig. 1).[19] The patient is positioned in a quiet environment behind a screen, with a template containing samples of shapes (cube, cylinder, and hexagon) and simplified textures (1, 2, and 3 0.5-mm raised metal dots placed in rows). Identification is performed with the index finger for median nerve disorders and fifth finger for hands with ulnar nerve disorders with instruction not to use the nail. The patient is instructed to identify the shape (of 3 degrees of difficulty, with 15, 8, and 5 mm diameters) and texture (also of 3 degrees of difficulty, with distances of 15, 8, or 4 mm between the multiple dots) of the randomly exposed objects. The test is performed in a standardized order. First, shapes of 15 mm are exposed to the uninjured hand and the injured hand, followed by shapes of 8 and 5 mm. The next step involved exposure to textures, beginning with the easiest, or largest, and always testing the uninjured hand before the injured hand. The uninjured hand is exposed first to ensure that the patient understands what the test is about. Each object is exposed only once. All 3 answers at each degree of difficulty for each test (shape or texture) have to be correct for the subject to score 1 point and proceed to the next degree of difficulty. The maximum score is 6 points, with possible scores ranging from 0 to 6 points, 0 to 3 points in shape identification, and 0 to 3 points in texture identification. The subject is informed of the scoring after completing the test.

The manufacturer of STI^2 is new (www.sensory-test.com), and the test differs very little from the original test instrument. The indentations for the texture dots are deepened to prevent the finger

Table 1
Demographic data

Data	Patient group	Healthy group	Total
Number of subjects	20	20	40
Gender			
Women	6	19	25
Men	14	1	15
Age			
Median	48	26	32
Range	15-71	22-43	15-71
Dominance			
Right	19	20	39
Left	0	0	0
Ambidextrous	1	0	1
Diagnosis			
Repair of median or ulnar nerve	5	na	
Repair of digital nerve	6		
Neuropathy	3		
Surgery of Dupytren's contracture	5		
Arthodesis PIP	1		

NA = not available; PIP = proximal interphalangeal.

Fig. 1. The shape-texture-identification (STI^2) in an assessment situation of an median nerve disorder.

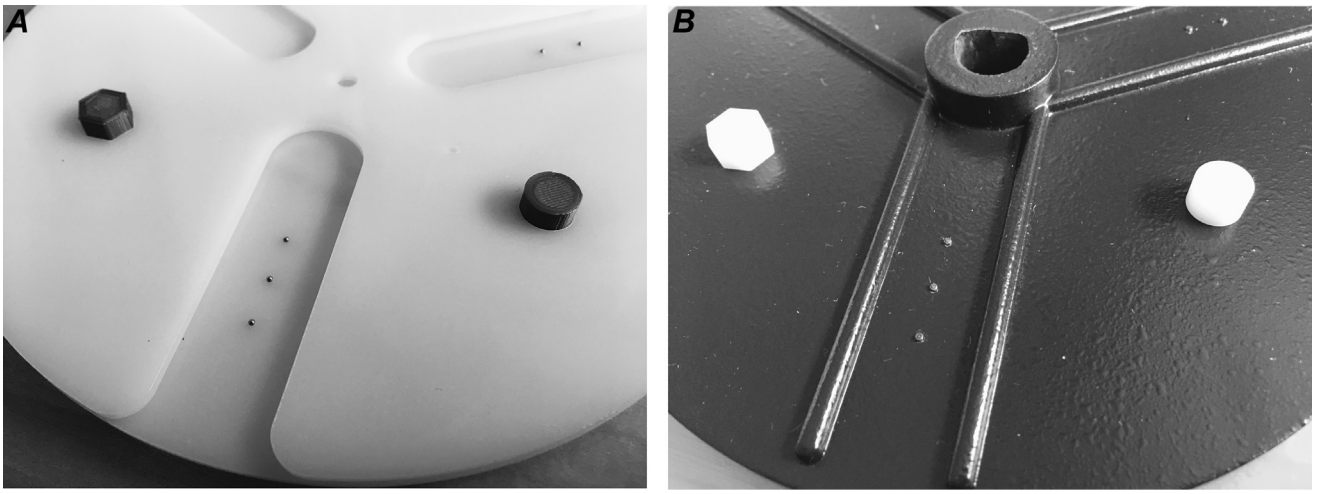

Fig. 2. (**A**, **B**) The indentations for the texture dots in of shape-texture-identification (STI^2) (**A**) are deepened to prevent the finger from slipping away from the slot.

from slipping away from the slot (Fig. 2), and the hard surface of the discs where the 3 different shapes and the 3 different textures are positioned is slightly smoother. Apart from that, the test looks identical to the original edition, and the test procedure is identical. The STI test has been in use in assessment of tactile gnosis for a long time now, and despite the relatively discrete changes in the design of the new STI^2, we find an investigation of a new version useful.

Procedure

The patient group was tested at the Department of Hand Surgery in Malmö and performed according to the STI test manual in a quiet environment, where the assessor and patient could sit uninterrupted. The most affected digit was the one assessed, and in accordance with the manual, the corresponding digit on the healthy hand was also tested. The test was performed as described previously.

The healthy group was tested at Health Science Center in Lund in a quiet room, where the assessor and patient could sit uninterrupted. The healthy group was tested in the same way as the patient group with the only difference, given the scope of the study, that both the index finger and fifth finger were tested. This was done to increase the total amount of assessment data represented by median and ulnar innervated fingers.

Each test subject was tested once with the original version of the STI test and once with the new version. The next test subject was tested in reverse order to avoid bias due to learning. Two different therapists (PL and JPE) performed the 2 tests, and they also switched between the 2 different versions of the test during the study period.

Data analysis

The agreement between the 2 versions of the instrument was calculated by a percentage comparison of the test results, and a weighted kappa calculation with 95% confidence interval was done. Data are presented in cross tables based on results with complete agreement, results with an accepted deviation of 1 point, and results with deviation of more than 1 point. This study is based on the assumption that 1-point difference between the 2 versions of the test is to be considered as good agreement. A previous methodological study has shown an accepted margin of error of 1 point between 2 assessments.[9]

The data were processed both on the basis by merging the groups ($n = 40$) and analysis of each group, containing ($n = 20$) each. In the patient group ($n = 20$), the injured finger and corresponding finger on the opposite hand was assessed. In the healthy group ($n = 20$), digits II and V were assessed on each hand. This could give a total data set of 120 assessed fingers.

The data were analyzed in IBM SPSS Statistics 23 (Statistical Package for the Social Sciences, version 23 for Mac; IBM Corp., Armonk, NY).

Results

Demographic data are presented in Table 1.

Among the patients, the internal loss was 2 participants; 1 person who interrupted the test because of pain and 1 due to lack of time, and in the healthy group, the internal loss was 1 person who interrupted the test due to lack of time.

The assessments showed complete agreement including the accepted 1-point margin of error of the instrument in 92% (103 fingers) of the assessments (Table 2). Of the 112 tested digits, there was a complete agreement in 74% of them (83 fingers). The percentage of assessments with the accepted 1-point deviation was 18% (20 fingers), and the ratio of 2-4 points difference was 8% (9 fingers).

In the patient group, complete agreement or 1-point accepted deviation between the 2 tests was 83% (15 fingers). Complete agreement of the affected fingers was 44% (8 digits), and the percentage of assessments with 1-point deviation was 39% (7 digits), and the ratio of 2-4 points deviation was 17% (3 digits) (Table 3).

Table 2
Complete agreement (dark gray) or 1-point accepted deviation (light gray) between the 2 tests in 92% and of the tested fingers of all participants ($n = 112$ fingers)

		STI							Total
		0	**1**	**2**	**3**	**4**	**5**	**6**	
	6					2	7	72	81
	5		1		1		8	8	18
	4		1		1	1	2	1	6
STI^2	**3**		1			1		1	3
	2		1	1					2
	1								0
	0	1							2
Total		1	4	1	2	4	17	82	**112**

STI = shape-texture-identification.

Table 3
Complete agreement (dark gray) or 1-point accepted deviation (light gray) between the 2 tests in 83% of the patient's affected fingers ($n = 18$ fingers)

		STI							Total
		0	**1**	**2**	**3**	**4**	**5**	**6**	
	6						1	4	5
	5					1	2	2	5
	4				1				1
STI^2	**3**	1				1	1		3
	2			1					1
	1			1	1				2
	0	1							1
Total		2	0	2	2	2	4	6	**18**

STI = shape-texture-identification.

In the healthy test group, both hands tested, the comprehensive result for the group was 95% (72 digits). Complete agreement was 87% (66 digits), and the percentage of assessments with 1-point deviation was 8% (6 digits), and the proportion of 2-4 points difference was 5% (4 digits).

There were no systematic differences between the 2 versions. In 14 of the assessments, a higher score was achieved on the old version of the test, and in 15 assessments, the score was higher on the new version.

Discussion

The results indicate that there is good concurrent validity in STI^2 when compared with the original version of the instrument. Given the instrument's accepted margin of error of 1-point difference, there was agreement in 92% of cases when all assessment data from patients and healthy controls were included. The results prove that the basic assumption in this study is true, that STI^2 does not diverge significantly from the original version.

The result also showed that there is no systematic deviation between the 2 versions. The minimal differences that were seen could be due to chance, time shortage, pain, and lack of concentration or difficulty in interpreting instructions. There was no significant difference in which version of the instrument participants performed best respectively worst on, which is crucial for the clinical implementation of STI^2. The internal loss of 3 subjects occurred randomly and should therefore not have had a significant impact on the outcome.

When this kind of instrument is used in the health care system, 2 errors can occur. One is that a person with a nerve disorder is classified as healthy (low sensitivity) and the other that a healthy individual is classified as having a nerve disorder (low specificity). The purpose of testing the healthy group was to capture the instrument's specificity, in addition to the sensitivity given from assessing the patients. Previous research has shown that STI has good specificity and sensitivity,[8] and because the results of this study show that STI^2 is in agreement with the original version, it is reasonable to assume that the sensitivity and specificity are also valid for the new version.

In order for STI^2 to maintain its value in a clinical context, it is important to be able to demonstrate that the concurrent validity is good, which the result of this study does. Time efficient but yet valid and reliable instruments such as STI^2 plays an important role in clinical practice. Recent research shows that the STI test has proven a reliable assessment instrument in the outcome process not only for peripheral nerve disorders but also on other groups of patients such as stroke patients.[12]

Evidence-based instruments are used in hand rehabilitation to systematically improve quality and ensure a safe and efficient health care system. MacDermid[20] states: *Assessment of outcome after nerve injury should include measures addressing motor and sensory function, pain, cold sensitivity, and dexterity. Quantitative sensory testing in autonomous zones should be conducted using validated and calibrated instruments. 2PD is not sufficiently responsive to detect change over time, but may indicate functional subgroups. Functional sensibility can be indicated using the Moberg pickup or the STI test. A comprehensive impairment scale that has been well validated for nerve injury should be used to make comparisons across centres and treatment approaches*. Documentation of the outcome of a nerve disorder based on valid and reliable measurements is thus paving the way for both national and international standards for clinical evaluation and clinical research.[14]

In cases of peripheral nerve injuries, as in all rehabilitation, a holistic view of the patient's situation is required. According to the World Health Organization International Classification of Functioning, it is important to lift the perspective from purely functional and body structure levels to also include the context regarding the individual's activities and opportunity for participation, as well as environmental and personal factors present.[21] The hand therapist has an important role to translate the result from the STI^2 test and make it a part of the patient's daily life by relating the training to everyday activities, thus avoiding rehabilitation aimed solely at functional training. A careful investigation of the patients' ability of tactile gnosis is therefore a prerequisite for finding the correct level of rehabilitation.

Assessment of outcome provides important feedback for the patient, therapist, and doctor during the rehabilitation period and should be performed in a standardized manner using evidence-based test instruments on a regular basis. The sensory relearning after a major nerve trauma is usually a long process, and the patient needs constructive feedback along the way to keep up motivation for a training that has several abstract elements. Good clinical documentation can be a useful tool in this process, and the patient should take an active role in the evaluation of the assessments. This may help him or her to plan the training together with the therapist and to focus on the weak and strong parts in the outcome. An instrument that is sensitive to subtle changes in details of specific functions and overall outcome over time is recommended. Several methods have been suggested over the years, and their pros and cons are discussed elsewhere in the literature. The Rosen score is a composite standardized diagnose-specific model instrument for use after nerve repair, which includes separate domains for sensory, motor, pain-discomfort, and also a total score with a long-term recovery curve.[11] For details in function after sensory relearning, the STI test is the choice in this model instrument, and an overall score can be determined and guide treatment planning.

The number of subjects is somewhat limited in this study, but the power can be considered sufficient to answer to the purpose of the study because the shortage of participants is weighed up by the amount of assessment data from 112 tested fingers. A shortcoming in the study is the lack of balance between tested healthy and affected fingers, and a larger number of patient data had further strengthened the result.

One hundred twelve tested fingers in 40 individuals might be of concern regarding independence of the single values. This might have influenced the rather narrow confidence interval but not the agreement between the 2 tests.

The authors consider the internal and external validity as strong because well-defined background information about the selection of participants, as well as strengths and weaknesses in the sample, have been reported. The guidelines and instructions for conducting the assessments have been followed to the highest extent, which

means that the reproducibility and generalizability of the study is considered to be good.

The approach to data collection was that 2 assessors tested each patient, one using the old version and the other the new edition. The advantage of this approach was the natural break between test occasions, which could reduce elements of learning. The disadvantage was that an additional variable in the form of intertester reliability was not taken into consideration, which this study did not intend to investigate. This also assumed to reduce the risk of systematic discrepancies due to the assessor's approach, although the testing was performed strictly according to the STI test manual.

Convenience sample can often generate a skewed result, but sometimes, it is an acceptable selection method. For this study, it is a suitable method as the anatomy and physiology of the hand does not differ between people in aspects that may affect the outcome of the STI test. Also, gender and age distribution, especially in the healthy group, were not critical to the outcome of the study.

Internal validity can be influenced by conscious or unconscious adjustments at the time of assessment and should be considered. During the assessments, it became clear that some learning occurred, most noticeably when participants responded more confidently and quickly after a while. Therefore, it was considered important to vary what version the participants started at each new test opportunity. Similarly, it was also observed that some incorrect answers were due to lack of concentration. This was especially evident in the healthy group, which was tested with 2 fingers on each hand, resulting in a longer session.

Conclusion

Previous research has shown that STI has good psychometric properties. This study demonstrates good concurrent validity in STI^2 and contributes to the scientific evidence of the instrument, thus enabling a clinical implementation. The use of standardized and evidence-based assessment tools in clinical practice is paramount for the patient-centered health care. The test results of STI-STI^2 can be used as 1 piece of the puzzle to identify to what extent the patients may experience activity imbalance in their daily lives due to impaired sensibility and guide the therapists' interventions during rehabilitation.

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1. Previous work has shown the STI[1] to be
   a. valid only when administered by personnel who are certified in STI[1]
   b. an acceptable tool for research only
   c. only moderately reliable for clinically testing shape-texture-identification
   d. an acceptable tool for clinically testing shape-texture-identification
2. The primary statistical measure to establish validity between testing methods was
   a. an ICC
   b. the Pearson Coefficient
   c. a weighted Kappa
   d. a linear Kappa
3. The two groups were
   a. twenty fingers of actual patients compared to 40 digits of normal subjects
   b. twenty fingers of actual patients compared to 20 digits of normal subjects
   c. forty fingers of actual patients compared to 20 digits of normal subjects
   d. forty fingers of actual subjects compared to 40 digits of normal subjects
4. The STI tests (STI[1] and STI[2]) are designed as a complement to the
   a. M2PD test
   b. 2PD test
   c. Sollerman test
   d. Moberg Pick Up test
5. The authors concluded that the newer version (STI[2]) was concurrently valid (compared to the STI[1]) for clinical use
   a. false
   b. true

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