Development of a Hand Sensitivity Test for the Hypersensitive Hand

(traumatic injuries, hand therapy, occupational therapy assessment)

Elizabeth J. Yerxa  Lois M. Barber  Olivia Diaz  Wendy Black  Stanley P. Azen

An instrument was developed to measure the effects of a desensitization program on hand hypersensitivity. It was standardized with 40 "normal" subjects ages 20 to 40 of both sexes and two ethnic groups. Results showed reliability coefficients ranging from .74 to .82 for the three modalities employed in the test. Analyses of variance of agreement between test and retest scores revealed no significant differences in reliability due to hand used, sex, or ethnicity. It was concluded that the instrument could be used as both a clinical and research tool for the measurement of hand sensitivity.

Patients who have had traumatic hand injuries may develop hypersensitivity of the hand as a result of amputation, scarring, crush injuries, neuromas, or burns (1). Hypersensitivity is defined by the authors as a condition of extreme discomfort or irritability in response to normally nonnoxious tactile stimulation. It occurs at or near the injury, in contrast to the more generalized pain found in causalgia or shoulder-hand syndrome. For example, a patient may be unable to use a hand for writing because of an inability to sustain contact with a pencil. As reported by Barber, over a 2-year period 40 percent of all patients seen at the Downey Hand Center demonstrated hypersensitivity (2). This group primarily consisted of those with hypersensitive scars, amputations, and crush injuries. Such patients often become more disabled in their activities than would be expected by the extent of tissue trauma since they avoid using the affected part or adopt poor motion patterns when using their painful, easily irritated hands. The resulting disability is of serious concern to occupational therapists who have as a primary goal the return of patients with hand injuries to the highest level of function in their daily occupations. Although treatment to desensitize hypersensitive hands is being used by occupational therapists, no instrument could be found to measure the effectiveness of such intervention.

Hypersensitivity as a result of traumatic injury has been described in the neurological and rehabilitation literature for decades (3-7). In the 1950s it was determined that tapping a hypersensitive stump with a wooden mallet often decreased pain and discomfort (6). Other writers discussed the beneficial effects of vibration, massage, pressure, and normal activity in desensitizing a hypersensitive part (4, 5, 7). These authors employed stimulation because they believed it would cause the degeneration of neuromata (6) or inhibit the transmission of pain impulses (8). However, theorizing about the neuro-

Elisabeth J. Yerxa, Ed.D., OTR, FAOTA, is Chairperson and Professor, Occupational Therapy Department, University of Southern California, Downey, California.

Lois M. Barber, OTR, FAOTA, was formerly Chief Occupational Therapist, Downey Hand Center, Downey, California, and is currently President, LMB Hand Rehabilitation Products, San Luis Obispo, California.

Olivia Diaz, M.S., CRC, is Rehabilitation Counselor in private practice, Pasadena, California.

Wendy Black, COTA, was formerly at Downey Hand Center, Downey, California.

Stanley P. Azen, Ph.D., is Professor of Family and Preventive Medicine and Biomedical Engineering, School of Medicine, University of Southern California, Los Angeles, California.
The Downey Hand Center Hand Sensitivity Test (DHCHST)
Downey Community Hospital—Hand Rehabilitation Center

<table>
<thead>
<tr>
<th>Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Downey Hand Center Hand Sensitivity Test (DHCHST)</strong></td>
</tr>
<tr>
<td><strong>Downey Community Hospital—Hand Rehabilitation Center</strong></td>
</tr>
</tbody>
</table>

1. Name _____________________ Age ______ Sex ______ Language Barrier Yes ___ No ___ Hispanic Yes ___ No ___

2. Diagnosis

3. Source of pain: Amputation ___ Scar ___ Crush ___ Neuroma ___ Burn ___ Other ____________________________

4. Description of painful area: Initial: ________________________________________________________________

5. Dominance: Right ___ Left ___ Discharge __________________________________________________________

6. How injury occurred

7. Date(s) of injury __________________ Date(s) of surgery __________________ Date of 1st Rx after surgery __________

8. No. of weeks from DOI to 1st Des. Rx: __________ No. of weeks from surgery to 1st Des. Rx: ______________

9. No. of weeks between 1st and last Rx: __________ No. of treatments __________ Referring M.D. __________

10. Occupation __________________ Return to work: Yes ___ No ___ Previous Job? Yes ___ No ___

11. Dowel Textures - Date Contact Textures - Date Vibration - Date

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

12. Int. Did the Desensitization Treatment affect your sensitivity today? Yes ___ No ___


15. 2 Wks Has the Desensitization Treatment affected your sensitivity? Yes ___ No ___


18. DC Did the Desensitization Treatment affect your sensitivity? Yes ___ No ___


20. How much? A Lot ___ Some ___ Very Little ___ Comments ____________________________

21. DC Which Treatment affected your sensitivity the most? ____________________________

**PHYSIOLOGICAL EFFECTS OF DESENSITIZATION TREATMENT**

The physiological effects of desensitization treatment is beyond the scope of this paper.

For the past 6 years, occupational therapists at the Downey Community Hospital Hand Rehabilitation Center have been treating patients who have hypersensitivity resulting from hand injuries (9). The desensitization treatment program employs short periods of contact with three sensory modalities: dowel textures, immersion or contact particles, and vibration. Each modality is given in a ten-step hierarchy of degree of irritation determined for the individual. Based upon the principle that each person's particular hierarchy of sensitivity can be assessed, treatment begins by exposure to a stimulus that is slightly irritating but which can be tolerated.

In order to evaluate the effects of this desensitization treatment, data were gathered on more than 200 patients, using a "Desensitization Record" that recorded the hierarchies attained with the three modalities. Since these data were incomplete
and imprecise, it was decided to develop an instrument to assess more objectively the results of the desensitization treatment in reducing hypersensitivity of the hand. In order to accomplish that goal the Desensitization Record was developed into a new instrument that could be used as both a clinical evaluation and research tool.

The purpose of this paper is to describe the development of this new instrument, the Downey Hand Center Hand Sensitivity Test (DHCHST), for use as a measure of the effects of a desensitization program on hand hypersensitivity. Desensitization refers to decreasing the sensitivity of the hand to an external stimulus. A description of the treatment will only be included in this paper as is necessary for understanding the rationale for development of the DHCHST. A detailed description of desensitization may be found in the second edition of Rehabilitation of the Hand (2).

Research Question
One research question was explored in this study: Would the Downey Hand Center Hand Sensitivity Test (DHCHST) demonstrate adequate reliability to justify its use as both a clinical and research tool in assessing the effects of a desensitization program on hand hypersensitivity?

Test Description
The test (see chart) is administered by instructing the patient to stimulate the hypersensitive hand area with three types of stimuli: dowel textures, contact particles, and vibration. These stimuli have been arranged in a predetermined hierarchy of irritation and numbered from 1 to 10, with number 1 representing the stimulus believed to be the least irritating and number 10 the most irritating. This original hypothetical hierarchy and the selection of the three modalities were based upon a consensus of ten experts in hand rehabilitation together with the literature (4-8), lending content validity to the instrument. However, after using the original hierarchy in clinical practice for several months, it was found that patients demonstrated individual differences in sensitivity that were at variance with how the stimuli had been ordered. It was then decided that each patient would be asked to establish an individual hierarchy of sensitivity to the graded stimuli included under dowel textures and contact textures. (Vibration is discussed below.) Thus, each stimulus within each modality was numbered 1 to 10 for identification only.

The numbers 1 through 10 printed on the DHCHST represent the positions on the patient's hierarchy. For the dowel and contact textures, the identification number of each stimulus is entered into the appropriate box in the initial column for the first assessment and in the DC column when treatment is terminated. Thus, if the stimulus with identification number 3 is perceived as the least irritating of the ten dowel textures, a 3 is recorded in the box next to number 1 on the dowel texture hierarchy.

The ten dowel textures range from moleskin to Velcro hook. A hierarchy of sensitivity to these textures is determined for each patient as follows: The occupational therapist randomly chooses one of the dowels, instructing the patient to rub, roll, and tap the texture over the hypersensitive area until he or she has an adequate sense of it (see Figure 1). Then the therapist randomly selects a second dowel and has the patient compare it with the first by asking, “Which of these is the more irritating?” This procedure is followed until all ten dowel textures...
are lined up from the least irritating (one) to the most irritating (ten) and that individual’s particular hierarchy is recorded.

Contact or immersion particles consist of particulate materials contained in 3-pound coffee cans so that a patient can immerse the whole hand into their contents. Textures range from cotton to sharp-edged plastic cubes. Again, the patient establishes a hierarchy of irritability from 1 to 10 that is recorded under “Contact Textures” on the test.

The vibration hierarchy employs two vibrators—a battery-operated vibrator with frequencies of 23 cycles and 53 cycles per second, and an electric vibrator with frequencies of 83 cycles and 100 cycles per second. The ten-step hierarchy was predetermined as for the other two modalities, but in the case of vibration, continues to be used as originally ordered because of its complexity. The vibration hierarchy is based upon a combination of cycles per second (ranging from 23 to 100), type of contact with the hypersensitive area (continuous or intermittent), and the amount of time vibration is applied. Since the vibration hierarchy is predetermined, only the dates of treatment initiation, change, and level of the hierarchy at discharge are recorded in the data column.

The DHCHST is used both for establishing a treatment program and for measuring progress in decreased hypersensitivity. Once the initial hierarchy is established for each modality, it is the means of determining which particular stimulus for each modality should initially be employed in treatment. For example, in establishing treatment for the dowel textures the patient is asked to select a dowel from his or her individualized hierarchy with a texture that can be tolerated in contacting the hypersensitive area for 10 minutes three or four times per day. The date on which treatment is initiated is then entered on the DHCHST in the “Date” column adjacent to that dowel.

As a research tool, the instrument is used to record changes in which stimuli can be tolerated for 10 minutes, three to four times per day. Progress is determined by the number of steps made up the patient’s individual hierarchy toward tolerance of the most irritating stimuli. Maximum progress consists of the patient’s being able to tolerate a stimulus he or she had initially responded to as number 10 on the individualized hierarchy.

At least weekly the patient receiving desensitization treatment is tested to determine if change has occurred—that is, whether a more irritating stimulus can be tolerated for 10 minutes, three or four times per day. The date of initiating treatment is entered for each modality next to the stimulus on the patient’s hierarchy that could initially be tolerated. In addition, the date upon which the patient is able to tolerate each increasing level of irritation is recorded next to that stimulus on the hierarchy for each modality. Other data useful in treatment assessment are also entered on the DHCHST at the time that treatment is initiated and terminated (see Chart).

Method of Test Development

Standardization. First, it was necessary to assure that each time an individual was assessed by the instrument the same directions were given by the occupational therapist. Thus, the instructions were written through a consensus of two occupational therapists and a certified occupational therapy assistant. They were then pilot tested on the staff of the Downey Hand Center for clarity and precision and revised as necessary.

Next, it was decided to determine how persons with “normal” hands responded to the stimuli. That is, would a person without hypersensitivity show a reasonable amount of consistency in the ability to establish an individualized hierarchy of sensitivity to the stimuli within each modality? (Persons with normal hands were selected to eliminate the contaminating factor of change in hand sensitivity.) This question was important in determining how much confidence one would have that changes in the hierarchy reflected changes in sensitivity rather than a lack of reliability of the instrument.

Sample Characteristics. A standardization sample of 40 “normal” volunteer subjects, ages 20 to 40, consisting of 10 male and 10 female Anglo-Americans and 10 male and 10 female Mexican-Americans was selected. Since approximately 75 percent of the patient population at the Downey Hand Center were Mexican-American males, it was also essential to find out whether differences in reliability existed due to ethnicity or sex. Differences, if present, would be important to recognize in interpreting the results of the desensitization.

An attempt was made to eliminate subjects with a history of hand injury. However, it was found that almost all had some previous injury. Therefore, “normal hand” was redefined as a hand without pain, neurological deficit, or skin abnormality. Thirty-eight subjects were right-handed, one was left-handed, and one characterized himself as ambidextrous. Subjects came from a wide variety of occupations including professional and techni-
Figure 2
Reliability testing on normal hand for dowel textures.

Reliability Testing Procedures. Reliability of the DHCHST had to be assessed in order to determine to what degree changes in patients' hand sensitivity were real changes or merely the result of error caused by an unreliable instrument. The question was: To what degree would a person with a normal hand establish the same hierarchy of sensitivity on two different occasions 2 weeks apart?

Subjects were tested on the dowel textures beginning with a randomly selected right or left hand and a randomly selected dowel texture. They were asked to produce a hierarchy of ten dowels arranged from the least irritating (numbered 1) to the most irritating (numbered 10) for each hand (see Figure 2). The same procedures were followed for contact textures and vibration for each hand. All testing was completed in one session lasting approximately 1 hour. Two weeks later all subjects were retested using the same procedures. Thus, data were collected twice for each hand for each subject. Three examiners participated in gathering data using the standard procedures.

Results
Reliability. In order to determine to what degree the test was reliable—that is, that the results were stable over time—the test data and retest data on each subject were compared for each hand and each modality using the Spearman rank order correlation. Reliability coefficients thus determined were as follows: Dowel textures right hand .77, left hand .79, contact particles right hand .74, left hand .80, and vibration right hand .82 and left hand .82. Since all reliability estimates were close to .80, a conventional cutoff point, it was concluded that the reliability of each of the subtests for both hands was sufficient for the use of the DHCHST as a research as well as a clinical tool.

Sex, Ethnic, and Hand Differences. Next, it was necessary to determine whether there were any significant differences in the reliability of the test if it were administered to men or women, Mexican-Americans or Anglo-Americans, or the right or left hands. If such differences were found, then the DHCHST might only be useful with a limited segment of the population or the results might have to be interpreted differently for one group, males, than for another, females. It would also be interesting to know if one group was more accurate in making discriminations and possibly might be more sensitive to the stimuli used in treatment.

For each modality, the Wilcoxon rank sum test was used to compare test/retest correlations between males and females and also between Mexican-Americans and Caucasians. For each modality, the Wilcoxon signed rank test was used to compare test/retest correlations between the hand being tested. Nonparametric tests were used since these are appropriate for nonnormally distributed data. As desired, all statistical tests failed to reach statistical significance (see Table). In other words, no significant differences in reliability were found due to sex, ethnicity, or hand being tested. Thus, it was concluded that the DHCHST could be used with both sexes, with Mexican-Americans and Anglo-Americans, and for both hands without anticipation of significant differences in reliability in determining a hierarchy of sensi-
tivity due to the effects of these variables. The findings lent further support to its use as both a research and clinical tool.

**Discussion**

The DHCHST appears promising as a measure of hand sensitivity to three forms of stimuli used in planning desensitization treatment and for objectively assessing the outcomes of such treatment for those with hypersensitivity of the hand. Future research needs to be done to replicate the reliability studies with larger, representative samples selected from other geographical areas. The confidence with which the instrument is used would be enhanced by assessment of other forms of validity. For example, to what degree do changes in the hierarchy reflecting decreased hypersensitivity correlate with other tests of hand function or even the frequency of spontaneous use of the hand?

Hochreiter recently demonstrated that vibration raised the tactile threshold for 5 and 10 minutes post-vibration in normal hands (10). Her findings lend support to the use of vibration as a short-term desensitization procedure and validate its inclusion in the DHCHST. Theoretical explanations as to why sensory stimulation could be expected to reduce hand sensitivity also need to be explored in greater depth.

Whether subjects are sensitive to the textures or the pressure exerted by the modalities employed is open to speculation. However, reliability in establishing hierarchies of dowel textures and contact particles demonstrates that normal persons have considerable fine discriminative abilities in differentiating these particular stimuli.

Descriptive research is currently being conducted on more than 100 patients at the Downey Hand Center to document the outcome of the hand desensitization treatment program. This research employs the DHCHST as one measure of progress. It is anticipated that occupational therapists at other hand centers will initiate similar studies with their patients who have hypersensitivity in order to further evaluate the effects of this treatment approach.

**Resources**

The complexity of the test materials and length of precise instructions preclude inclusion in this paper. Detailed DHCHST instructions and test materials are available from: LMB Hand Rehab Products, Inc., P.O. Box 1181, San Luis Obispo, CA 93406. The vibrators employed in testing may be obtained from Fred Sammons, Inc., 145 Tower Drive, Burr Ridge, IL 60521 (#BK 5207 and BK 5209).

**Table**

Average Correlation Coefficients Stratified by Modality, Ethnicity, Sex, and Test Hand

<table>
<thead>
<tr>
<th>Modality</th>
<th>Ethnicity</th>
<th>Sex</th>
<th>Avg. Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dowel</td>
<td>Mexican-American</td>
<td>M</td>
<td>.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>M</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.84</td>
</tr>
<tr>
<td>Contact</td>
<td>Mexican-American</td>
<td>M</td>
<td>.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.72</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>M</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.75</td>
</tr>
<tr>
<td>Vibration</td>
<td>Mexican-American</td>
<td>M</td>
<td>.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>M</td>
<td>.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>.85</td>
</tr>
</tbody>
</table>

Tests of significance comparing ethnicity, sex, and test hand were all nonsignificant.