The Southern California Postrotary Nystagmus Test and Electronystagmography Under Different Conditions of Visual Input

(occupational therapy, sensory integration, vestibular function test)

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This study assessed the Southern California Postrotary Nystagmus Test (SCPNT)-stimulated nystagmus under three conditions of indoor illumination (bright, dim, and dark), and it studied the concurrent validity of SCPNT and electronystagmographic (ENG) measures of nystagmus duration and excursion. Eighteen adult subjects received three sets of rotations to the left under different lighting conditions in a counterbalanced order. The duration and excursion of the SCPNT were monitored under the bright and dim conditions, and ENG-recorded duration, excursion, frequency, slow-phase velocity, and average intersaccadic interval were measured under all three lighting conditions. No significant differences were found between nystagmus duration or excursion under the bright and dim conditions, but highly significant differences were found between the dark condition and the other two conditions. The correlation between ENG-recorded duration and SCPNT visually monitored duration across bright and dim conditions was .73, and the correlation for excursion was .24. These results suggest that occupational therapy researchers and clinicians need not question the validity of SCPNT procedures under different indoor lighting conditions, and suggest that the concurrent validity of ENG recordings and SCPNT measures requires more study.

One of the major tasks of occupational therapy research is the study of the validity of instruments widely used in clinical evaluation. The Southern California Postrotary Nystagmus Test (SCPNT) (1) has been used frequently by occupational therapists, and research has suggested that this instrument has value in the identification of subcategories of sensory integrative dysfunction (2, 3), as a predictor of response to therapy (4), and as a test-retest measure of change due to therapy (5, 6).

Though standardized on children five to nine years old, the SCPNT has recently been studied or used with preschoolers (7, 9) and with blind (10) and retarded (11) adults. Two studies comparing different types of schizophrenic populations to normal adults in terms of postrotary nystagmus used adaptations of the SCPNT; one study used a rotating chair instead of the SCPNT board (12), and the other used Frenzel...
glasses in an attempt to rule out the effects of ocular fixation (13).

The SCPNT is designed to evaluate vestibular system function. Ayres has hypothesized that postrotary nystagmus of abnormally short duration may result from overinhibition of the vestibular nuclei or from inadequate sensory excitation of the vestibular nuclei (1). Whereas the vestibular system has a broad set of functions, including the regulation of body movement and the maintenance of a stable visual field (14), vestibular dysfunction could interfere with much of occupational performance.

A possible problem of validity faced by the SCPNT as a measure of vestibular function, however, results from research indicating that visual input interacts with the vestibular input provided by rotation under lighted conditions (15). Light per se may influence postrotary nystagmus, or the opportunity to fixate visually on objects while rotating in a lighted room may influence nystagmus (16). For example, Ritvo et al. (17) found that the duration of postrotary nystagmus was significantly different between an autistic group and a normal group when rotated under lighted conditions, but that differences were not significant when groups were rotated in the dark. The clinical implication is that a deficient SCPNT score might be due either to a vestibular dysfunction or to a dysfunction in the interaction between the vestibular and visual systems. Another implication of the possible influence of visual input on SCPNT scores relates to the fact that SCPNT testing is routinely done under different conditions of illumination in various clinical settings.

Occupational therapy researchers (6, 11) have recognized electronystagmography (ENG) as a sophisticated method of measuring nystagmus, but only Keating (18) has investigated the concurrent validity of the SCPNT through the electronic measurement of postrotary nystagmus. The ENG, as noted by Bhatara et al. (19), can measure not only nystagmus duration and excursion but also other variables of possible significance to the understanding of disabled populations, including the frequency of nystagmus beats, the intersaccadic interval (the interval between successive fast phases of nystagmus), and the velocity of the eye movements.

The present study poses the following questions: (1) How does postrotary nystagmus differ under three different levels of illumination? (2) Can the concurrent validity found by Keating between the SCPNT and ENG be confirmed? In addition, this study provides descriptive data in regard to the frequency of nystagmus beats, the intersaccadic intervals, and the slow-phase velocities characteristic of postrotary nystagmus as stimulated by SCPNT procedures.

Method

Subjects. Criteria established for inclusion in the study were as follows: (1) age between 18 and 35 years; (2) lack of any history of ear disease except for temporary past inflammations; (3) lack of any history of vestibular disorder; (4) lack of any ocular or visual disorder except for mild nearsightedness or farsightedness; and (5) lack of any current illness. Subjects refrained from caffeine and alcohol for at least 8 hours prior to the study, and they refrained from all prescription and nonprescription drugs except birth control pills for at least 48 hours prior to the study. Subjects wearing contact lenses removed them at least 20 minutes before the study. Eighteen subjects (ten females and eight males) were included in the study. One of the included subjects had to be retested a week later because of difficulties maintaining a constant rate of rotation during his first set of trials. Data on one additional subject were excluded because he became nauseous before the end of the procedure. The mean age of included subjects was 25.5 (SD = 4.8).

Apparatus. For ENG recordings, a Model 7 Polygraph was equipped with a 7P21 Nystagmus Differentiator, a 7P1 Preamplifier, and a 7DA Driver Amplifier. The input selector of the 7P1 was switched to the TC.8 position because pilot studies demonstrated that the DC settings occasionally resulted in drifting from the baseline. During testing, the speed of the polygraph paper was 25mm per second. Beckman miniature electrode collars and Beckman electrode gel ensured stable, accurate recording of the corneoretinal potentials associated with eye movement.

For SCPNT recording, all procedures described in the SCPNT manual (1) were followed by a registered occupational therapist certified in the administration of the SCPNT. Test-retest reliability and interrater reliability (1) have been established for the SCPNT.

Procedure. After reviewing each subject's eye, ear, and vestibular history, one of the experimenters inquired about recent caffeine, alcohol, and drug use. Next the subject helped prepare his or her skin for the electrodes by rubbing al-
cohol-saturated cotton swabs on the external canthus of each eye and on the center of the forehead. The skin was prepared further by one of the experimenters applying and removing Deaver Onni Prep with Q-tips. Having readied the electrodes with collars and electrode gel, another of the experimenters applied the ground to the forehead and the other two electrodes to the external canthi in such a way that the electrode centers were on a plane with the subject's pupils. Subjects whose ohmmeter readings indicated electrode impedance greater than 5,000 ohms were disconnected from the electrodes, and the skin preparation was repeated. Each subject was then instructed to sit on the SCPNT rotary board, and the electrode wires were twisted 15 times over the subject's head in a clockwise fashion so that the experimenter could hold the wires above the subject's head during the 30 rotations to the left without either disconnecting the electrodes or excessive twisting of the wires.

The electrode wires were inserted into the polygraph apparatus so that movement of the eyes to the right would result in an upward deflection of the pen on the primary (7P1) channel, whereas left-sided movement would result in a downward deflection. Prior to each set of rotations, pen deflection was calibrated at 1.5 cm per 10 degrees of eye movement by instructing the subject to move his or her gaze from a straight-ahead point to points 10 degrees to the left and right. After calibration, a sheet was drawn down covering the calibration points of the wall, and the subject was instructed about the SCPNT procedures according to the SCPNT guidelines. The subject's last spin terminated with facing the sheet-covered wall. The perrotary visual stimuli present in the testing room under lighted conditions were similar to many clinical conditions, with the room containing a desk, a file cabinet, and chairs.

Each subject received three sets of ten rotations to the left under three different conditions of visual input: bright, dim, and dark. The three conditions were randomly counterbalanced to assess any possible order effects, and there was a minimum of five minutes between each set of rotations. In the bright condition, the room was lighted by eight 20-watt and eight 40-watt overhead cool white fluorescent bulbs, and the mean of three photometric readings of the sheet-covered wall from the perspective of someone sitting on the nystagmus board was 439 footcandles. In the dim condition, all but two of the bulbs were disconnected, resulting in a mean photometric reading of 109 footcandles. In the dark condition, all the lights were turned off, light was prevented from otherwise entering the room, and the small indicator lights on the polygraph were not in the subject's line of vision. Pilot testing revealed that subjects were not able to visualize any aspect of the environment under the dark condition. Analysis of perrotary data indicated that the prior training received by the experimenter administering the rotations was adequate to ensure standardized rotations without visual input. Instead of referring to a stopwatch when timing the rotations, the experimenter received tape recorded timing signals via an earplug.

Postrotary nystagmus was assessed both by the ENG and SCPNT procedures in the bright and dim conditions, but it could be assessed only by the ENG in the dark condition because the room remained darkened for two minutes after the rotation, the maximum amount of time during which ENG recordings were made.

Data Reduction. Visually monitored duration and excursion were scored and recorded in accordance with SCPNT guidelines. Electronystagmography (ENG) recordings taken under bright, dim, or dark conditions resulted in the following scores:

1. Duration—the number of seconds prior to the first two-second interval in which there was no recording of any part of a nystagmus beat (a beat was defined as a rapidly upward-sloping line on the polygraph paper representing at least 1 degree of eye movement followed by a less acute, continuous downward deflection);

2. Frequency—the number of beats occurring during the total duration;

3. Excursion—the mean degrees of saccadic eye movements occurring in the first five seconds of postrotatory nystagmus;

4. Average intersaccadic interval—five seconds divided by the frequency of beats within the first five seconds of postrotatory nystagmus;

5. Slow phase velocity—the average degrees per second of the beats occurring in the first five seconds of postrotatory nystagmus, as calculated by dividing each beat's excursion by its duration in seconds and computing the mean. Slow phase velocity was calculated manually from the 7P1 channel recorder instead of being calculated from the 7P21 channel recorder because the 7P21 velocity output is not accurate for relatively small nystagmus beats.
Results
There were no significant differences between visually monitored (SCNPT) duration under bright versus dim conditions, \( t(17) < 1.0 \) (see Table 1). Visually monitored (SCPNT) excursion was the same under bright and dim conditions for each subject.

To compare ENG-recorded duration under the three conditions and to assess any possible order effects, a two-way (order \( \times \) lighting condition) analysis of variance (ANOVA) with one repeated measure was computed. Results indicated significant differences among lighting conditions, \( F(2, 30) = 48.2, p < .01 \), and subsequent Newman-Keuls post hoc analysis indicated that the dark condition duration was significantly greater than the other two conditions \( (p < .01) \), but that there were no significant differences \( (p > .05) \) between the bright and dim conditions. There was no significant order effect or interaction between order and conditions.

The same type of ANOVA and post hoc comparison was computed on each of the other ENG-recorded variables. Results indicated significant differences \( (p < .05) \) between the bright and dim conditions on ENG-recorded frequency, excursion, and slow-phase velocity. On average intersaccadic interval there were no significant differences among the three conditions. In none of the variables was there a significant order effect or an interaction between order and condition.

In studying the concurrent validity of the SCPNT duration and ENG duration, Pearson product-moment correlations were computed. The correlation between the SCPNT score of duration under the bright condition and the ENG score under the same condition was \( r(16) = .75 \). Under the dim condition, the correlation was \( r(16) = .56 \). When SCPNT scores for each subject were added together and when ENG scores were similarly added together, \( r(16) = .73, p < .01 \).

In studying the concurrent validity of SCPNT excursion and ENG excursion, the point biserial correlation under the bright condition was .20, and under the dim condition it was .20. When SCPNT scores were added together and when ENG scores were added together, the correlation was .24.

Discussion
Perhaps the most important finding in this study is that SCPNT testing procedures are not influenced by the degree of illumination present in the testing environment, at least between the range of 109 to 439 footcandles. This was confirmed both through SCPNT scoring and ENG scoring. The sets of means are so close to each other that there is little chance of Type 2 errors (failing to find differences when differences do indeed exist). On the other hand, the differences between postrotary nystagmus duration in the dark and its duration under lighted conditions are substantial (mean ENG-recorded duration was more than three times as great in the dark as it was under the other two conditions). Similarly, bright and dim conditions were similar to each other in terms of ENG-recorded excursion, frequency, and slow phase velocity, but the dark condition recorded substantially different scores on these variables.

The clinical implication of this is that the validity of the widely used

<table>
<thead>
<tr>
<th>Lighting Conditions</th>
<th>SCPNT Measures</th>
<th>ENG Measures</th>
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<tbody>
<tr>
<td>Bright</td>
<td>18.3 4.5</td>
<td>18.8 6.9</td>
</tr>
<tr>
<td>Dim</td>
<td>17.9 4.6</td>
<td>18.8 6.0</td>
</tr>
<tr>
<td>Dark</td>
<td>59.3 24.5</td>
<td>57.3 24.5</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Excursion (^1)</th>
<th>Bright 2.3 0.5</th>
<th>Dim 2.3 0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Bright 34.0 12.3</td>
<td>Dim 33.6 11.2</td>
</tr>
<tr>
<td>Slow-phase velocity—first 5 seconds</td>
<td>Bright 21.5 7.0</td>
<td>Dim 21.7 8.1</td>
</tr>
<tr>
<td>Average intersaccadic interval—first 5 seconds</td>
<td>Bright 0.4 0.1</td>
<td>Dim 0.4 0.1</td>
</tr>
</tbody>
</table>

\(^1\) SCPNT excursion is measured on a 3-point scale, and ENG excursion is measured in average degrees of eye movement associated with saccades occurring in the first 5 seconds.
SCPNT duration scores is not affected by testing under a wide range of indoor lighting conditions. Short et al. (8) are among those who have expressed concern for the validity of the SCPNT under different lighting conditions, and the present study should allay these concerns. However, it is still possible that SCPNT testing under conditions of natural sunlight might influence results, and the concern of Short et al. for the possible effects of visual fixation due to different kinds of visual stimuli in the environment remains an open question.

Though the correlations between SCPNT duration scores and ENG duration scores were statistically significant, it was somewhat surprising that even higher correlations were not found. Keating (18) found a correlation of .899 between SCPNT duration and ENG duration when 20 adult subjects’ right-rotation scores were added to their left-rotation scores. Based on Keating’s study, the authors of the present study anticipated a positive association greater than the .73 correlation actually found when the two left-rotation scores were added together. On an ex post facto basis, ENG records for the present study were repeatedly scrutinized to see if some other operational definition of nystagmus duration might result in greater agreement between ENG and SCPNT scores. For example, ENG duration was computed when a beat was operationalized as a 2-degree movement instead of as a 1-degree movement, and different rules concerning the length of time required during which no nystagmus beat could occur prior to the defined conclusion of nystagmus were examined. In all cases the subsequent correlations between the newly defined scores of duration and the SCPNT scores declined rather than increased.

The discrepancy between Keating’s study of nystagmus excursion and the present study’s excursion results is greater than the duration discrepancy. Keating reported a correlation of .608, whereas a correlation of only .24 was found in the present study. In the present study, excursion was calculated as the mean excursion of all beats occurring in the first five postrotary seconds, but Keating’s operational definition of ENG excursion is not clear. In any case, the clinical implications of nystagmus excursion are not nearly as important as those of nystagmus duration, because SCPNT duration is much more widely relied upon by evaluators and researchers than nystagmus excursion.

Further study of the concurrent validity of SCPNT scores and ENG scores is warranted. Greater sample size should increase the power of the correlation, for example. However, even if such study confirms less than perfect agreement between the two instruments, this will not necessarily mean that the ENG is necessarily accurate and the SCPNT somewhat inaccurate. For example, ENG recordings can occasionally be confounded by extraneous variables, such as voluntary eye movements, blinking, or electrical activity produced by the masseter muscles. In addition, analysis of ENG recordings suggests that the measurement of nystagmus duration is inherently problematic for several reasons: (1) otherwise acceptable beats often occur after the two-second interval formally defining the end of nystagmus; (2) small beats representing less than 1 degree of eye movement sometimes occur toward the end of postrotary nystagmus; (3) square waves in which right-beating saccades are followed by left-beating saccades are often difficult to distinguish from true nystagmus beats that have clearly defined slow phases; (4) slow phases are usually somewhat jagged in appearance, and therefore, it is difficult to determine the end of each slow phase; and (5) in contrast to postrotary nystagmus in the dark, postrotary nystagmus under lighted conditions is less rhythmic in terms of its intersaccadic intervals. Most of the discrepancies between SCPNT scores and ENG scores in this study could be explained in part by one or more of the above factors. In particular the SCPNT score appeared more likely to deviate from the ENG score when ENG recordings indicated an arrhythmic nystagmus and varying excursions within a subject’s pattern of nystagmus. Rhythmicty and regularity in nystagmus may be cues used by SCPNT testers.

Further studies might investigate the characteristics of various features of ENG-recorded postrotary nystagmus in both normal and clinical populations. For example, how does nystagmus duration, excursion, frequency, slow phase velocity, and intersaccadic interval compare between schizophrenic subjects and matched controls and between learning-disabled children and matched controls? Might these variables predict responsiveness to therapy, and is it possible that postrotary nystagmus in the dark is a better predictor than in the light? Granted that SCPNT duration scores are significant in the identification of subcategories of clients, in the predic-
tion of response to therapy, and in the measurement of change caused by therapy, is it possible that ENG recordings might improve these processes of identification, prediction, and documentation of change?

Conclusion
This study presents data supporting the validity of SCPNT testing under different conditions of indoor illumination. Further research of the concurrent validity of SCPNT and ENG procedures is warranted, however. Recommended for the future are studies of client populations that use electronystagmography as well as other measures of sensory integrative function and outcome.

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REFERENCES