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August 2008 , Page 56

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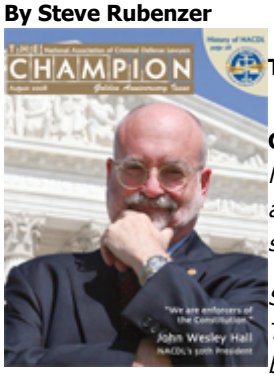

Ten Things You Probably Don't Know About the Horizontal Gaze Nystagmus Field Sobriety Test

Glossary

Nystagmus — Rhythmic movements of the eyes, usually consisting of a drift away from the target, followed by a saccade to bring the eyes back on target. The initial part (drift) represents error in the visual system; the saccade serves a corrective function.

Saccades — Fast, purposeful eye movements that are qualitatively different than smooth pursuit movements. They may shift the eyes from one target to another, or if an object moves away or is temporarily "lost," will bring the eyes back on target.

The Horizontal Gaze Nystagmus (HGN) test has been the subject of many articles, by both the prosecution and defense, since the introduction of the Standardized Field Sobriety Tests (SFSTs). Psychologists, ophthalmologists, toxicologists, and of course lawyers have all weighed in. However, only optometry, as a profession, has taken an official stand. In 1993, the American Optometry Association (AOA) House of Delegates passed a resolution endorsing HGN as a reliable and valid tool for field sobriety testing, a position that was reaffirmed by the AOA Judicial Council in 2000 and 2003.[1] Despite the AOA resolution, there is considerable vision science research that casts doubt on some HGN assumptions and claims.

About a year and a half ago, I learned the University of Houston College of Optometry offered a course in eye movements. I was lucky enough to run into the professor during my first reconnaissance trip to the college, and fortunate that he was willing to let me take his class. Throughout the semester, we talked about HGN. When the semester was over, we compiled a paper[2] reporting everything I could find relevant to HGN. Below, I present some of the highlights of what we found. Note that in many sections, I refer to breakdown of smooth pursuit specifically rather than to nystagmus. This is because there is far more research on smooth pursuit, and many of the issues have not yet been investigated for gaze nystagmus.

1. The NHTSA-recommended speed for breakdown of smooth pursuit (SP) may be very close to the maximum pursuit velocity without visible saccades for many people when sober, even under favorable conditions. NHTSA recommends a speed of two seconds from midline to far gaze (typically about 60 degrees), which corresponds to about 30 deg/sec. Several studies have reported that this is about maximum velocity for smooth pursuit.[3] However, several studies have reported that normal subjects show a substantial number of sizable saccades at speeds of 30 deg/sec or less.[4] It should be noted that other authors have reported that higher SP speeds without saccades are possible,[5] although as with nearly all eye movement studies, they employed young, healthy subjects. In any case, defense attorneys should understand that the speed of smooth pursuit is not an arbitrary parameter of the standardization, but one which, if violated, is likely to produce nystagmus even in sober persons.

The analysis above is based on the average speed the SP passes. However, many HGN videos reveal that the SP passes are not uniform in speed. Even if the average speed is within limits, variations in speed mean that the stimulus moved too fast during parts of it. In addition,

predictable stimuli are followed better than unpredictable targets.[6]

2. According to the largest study of its kind, about 10 percent of people have onset of nystagmus before 45 degrees of lateral deviation of the eyes at 0.00 percent BAC; another 10 percent have onset of nystagmus at 45 degrees.[7] In other words, it is not uncommon for sober people to have nystagmus when looking to the side 45 degrees, and the accurate measurement of this angle is vital.

3. Age has a considerable effect on SP. The rate of maximum smooth pursuit falls beginning by the 30s.[8] While younger subjects are able to maintain SP to targets moving 30-40 degrees per second, the elderly subjects showed nystagmus when targets exceed five degrees per second.[9] Surprisingly, although range of eye movements decreases with age,[10] older people may actually do better at maintaining their gaze to the side without nystagmus.[11]

4. HGN is (sort of) a divided attention task. A number of studies have shown that distractions, including performing mental arithmetic, can impair smooth pursuit,[12] although results have not always been consistent. Barnes and Crombie[13] reported SP was "heavily influenced by the presence of any unintended static peripheral cues, hence the need to operate in conditions of complete blackout."

5. Background characteristics can lower SP quality and result in nystagmus. This is especially true of backgrounds with strong vertical lines or with high interest value (seeing a tow truck hook up your car).[14] Backgrounds that are moving in the opposite direction of the stimulus (such as traffic) create large interference effects, whereas those moving in the same direction as the SP stimulus tend to facilitate performance.[15]

6. The listing of causes of nystagmus other than alcohol given in cases such as Schultz v. State is neither complete nor scientifically well-documented. However, there are good sources. The authors of an authoritative text[16] reported that many medical conditions affect SP and produce gaze nystagmus, including Parkinson's disease, progressive supranuclear palsy, cerebellar disorders, hepatic encephalopathy, Alzheimer's disease, and large cerebral lesions. Hartje et al.[17] reported that patients with unilateral lesions (vascular, neoplastic) or diffuse brain damage (epileptics, degenerative diseases, inflammatory, traumatic) showed many large saccades during SP. Another group of researchers found 76 percent of patients with a confirmed diagnosis of MS, and 25 percent of patients with optic neuritis, showed impaired SP, which manifested as a greatly increased number of saccades to stimuli moving more than 35 deg/sec.[18] Abnormal SP was found in 46 percent of patients with generalized vascular disease, such as long-standing hypertension, diabetic vasculopathy, and arteriosclerosis.[19] Citek[20] reported that hypoglycemia will produce disruption of SP, but no other eye symptoms.

Aside from neurological or muscular dysfunction, physical obstructions, such as a tumor in the eye socket, can impair smooth pursuit. In Brown's syndrome, the motion of the superior oblique muscle is obstructed in its passage through the trochlea, a structure that channels the muscles' action 90 degrees from its origin. Barbiturates and other depressants impair SP, as do medications used to treat pain, seizures, agitation, mood swings, anxiety, and insomnia[21] (See Table 1).

7. A number of psychiatric conditions affect SP. This is best documented for psychosis and schizophrenia, those at risk for such conditions, and their first degree relatives.[22] About 50 percent of acutely manic patients show impaired SP, while impairment in such patients in remission may be due to lithium treatment.[23] A mixed group of "26 neurotics undergoing therapy" showed larger and much more frequent saccades than did the normal control group, although considerably less than the neurologically impaired sample.[24] Abnormal SP has been found associated with self-report depression scores,[25] but not Neuroticism[26] scores.[27] Although children with ADD often show poor SP performance, the only study to examine SP in ADD adults did not find significant impairment in most subjects.[28] However, another study found such adults did show difficulty maintaining gaze away from the midline, making inappropriate saccades away from the target.[29] These could easily be mistaken for gaze nystagmus. Lastly, 42.4 percent of chronic alcoholics were found to have impaired SP, marked by prominent saccadic movements, compared to 20.0 percent of age-matched controls.[30]

8. Nicotine affects smooth SP, but its effects are complex. It has been reported to improve the SP of schizophrenics (who normally

show poor SP), and one study reported smoking a single cigarette impaired SP,[31] although several others reported no effects or even improvements. Nicotine ingestion has been reported to increase square wave jerks,[32] a pair of saccades (saccade away from target, pause, saccade back to target) that could easily be mistaken for alcohol-induced nystagmus.

9. Nystagmus probably does not significantly affect vision acuity. Laboratory studies suggest that very brief periods of visual fixation (i.e., 50 msec.) are sufficient to maintain normal visual acuity.[33] Further, people usually move their head when looking at a target more than 15 degrees from the center line,[34] so the nystagmus at maximum deviation, or near 45 degrees, is of little relevance. The only time this is likely to come into play is while looking in the side mirrors, and someone who experiences problems seeing would only need to turn his or her head.

10. The reliability of HGN and its constituent parts (breakdown of smooth pursuit, nystagmus during gaze to the side) is problematic. I am referring to "reliability" in its scientific sense, which means consistency, or replicability, across modes or occasions of measurement. Typical standards for tests used for individual decision making (as opposed to research on groups of individuals) range from the .80 figure advocated by Heilbrum[35] to the "bare minimum" of .90 recommended by Nunnally and Bernstein.[36] The reliability coefficient can be interpreted as the percentage of reliable variance in the test or measure, so that a test with a reliability of .90 contains 90 percent true variance and 10 percent error. The 1981 laboratory study[37] and Citek's 2003 study[38] reported inter-rater reliability (agreement between two officers) figures for HGN ranging from .59-.71. Similar figures were reported for test-retest reliability. Citek's study involved SFST instructors and, like most studies of eye movement, used only young, healthy subjects. Although sometimes cited as evidence of HGN's reliability, Citek et al. shows just the opposite: that 29-41 percent of the variance in HGN scores is due to administration or scoring differences among SFST experts. And that is with the tough cases removed ahead of time.
Two studies have examined the reliability of smooth pursuit performance and gaze nystagmus using instruments for both administration and recording. Ettinger et al.[39] found good retest reliability for SP measures when the stimulus moved 36 or 48 deg/sec., but not at 12 or 24 deg/sec. These authors did not examine alcohol-dosed subjects. Mundt et al.[40] did, and found moderately low (.65) test-retest reliability. In addition, the performance of the subject when sober was almost as strongly related to performance at .08 percent (r = .55) as was performance during a previous drinking session. Examining measures of gaze nystagmus, Mundt et al. found the test-retest correlation for subjects tested and retested at 0.00 percent BAC was .55, as it was for subjects tested and retested at approximately .08 percent.

In sum, the administration and scoring of different HGN examiners are sizable sources of error and indicate the test, as currently implemented, is not objective. This is a major barrier to accuracy in the field use of HGN. Further, the quality of eye movements themselves is not very consistent across time, whether the subject is sober or under the influence. Reliability is a fundamental requirement of any test (or phenomenon), as without it, observations and results are inconsistent and untrustworthy. This is probably the most profound problem with HGN from a scientific perspective.

Open Questions and Unresolved Confounds

Many potentially confounding variables have not adequately been investigated or addressed at all in published or thoroughly described studies. These include the effects of low temperature, wind, rain, and interactions with prescription medications. But perhaps no possible confounds are as common, and therefore as important, as fatigue and anxiety.

Fatigue is sometimes reported to impair SP in respected texts,[41] although often without supportive references or ones that, upon inspection, fail to support the assertion. The available evidence on the issue is very sparse: Barnes and Crombie[42] stated that the nystagmus they observed was "susceptible to changes in arousal, responses diminishing with increased drowsiness," but presented no quantitative data. Another study examined a single subject after 30 hours without sleep, and reported that tracking of a moving target was almost entirely saccadic. The SFST creators reported that the angle of onset of nystagmus under the influence of alcohol decreased after midnight, but no effect on sober subjects was observed.[43]

Booker[44] reported fatigue, defined as 30 hours of wakefulness and 13-14 hours of continuous mental and physical activity, caused 55 percent of subjects to show the HGN clue of distinct nystagmus at maximum deviation in one or both eyes. Conversely, in an unpublished study, prosecution expert Citek reported that fatigue does not cause eye movements likely to be confused with alcohol-induced HGN.[45] In sum, the literature is marked by a complete absence of peer-reviewed, formal studies regarding the effects of fatigue on SP, with one anecdotal report of severely impaired performance. There is a single published study indicating fatigue is a significant factor in endpoint

gaze nystagmus, with two or three unpublished ones reporting it is not. Clearly, more research is needed before any firm conclusions can be drawn.

Only one study has examined the effect of experimentally induced stress/anxiety on nystagmus.[46] It found no effect on SP, while the effect on gaze nystagmus was not examined. Since some variables (ADD, age) appear to have different effects on gaze nystagmus than SP, this factor requires more study.

Recently, NHTSA released a long-awaited paper[47] that examined the effect of administration errors on HGN. Three studies examined the effects of moving the stimulus twice as fast as directed, of holding the stimulus at or substantially above eye level, and of holding it either too close or too far away. Basically, no detrimental effects of these variations were found. However, the real bombshell result is not reported. Whether administered in normal fashion or not, false positive rates, defined as four or more HGN clues at less that .08 percent BAC, were 57-77 percent. Even for subjects at .05 percent and below, the false positive rate exceeded 70 percent in two of three studies using the standard protocol! Rather than proving HGN is robust despite variations in administration, the paper actually shows that it may be unsatisfactory in any guise.[48] There are other significant problems with the paper and it is not peer-reviewed, so until its findings are replicated, it is premature to conclude that HGN administration errors do not matter.

Conclusion

A thorough review of the eye movement literature finds many issues that question the propriety of HGN's use and other important considerations that have not been thoroughly explored. So far, no study has demonstrated HGN's validity, accuracy, or error rates when not used in conjunction with other observations and statements by the subject. Equally as important, HGN has never been validated as a test of mental, physical or driving impairment.[49] Other areas of concern include the effects of age, medical and psychiatric conditions, medications, and environmental conditions, and the limited reliability of eye movements themselves.

Despite HGN's acceptance by many courts, there are numerous factors that challenge its status as a scientific test. The standard administration of HGN, even when in strict concordance with NHTSA standards, may not be scored reliably and may generate substantial false positive errors when applied to subjects who are not young, rested, and healthy — or have been drinking within legal limits. Contrary to some assertions,[50] there is no published evidence police officers can distinguish HGN from other jerky movements of the eye.

Proponents of HGN have an obligation to demonstrate not only that the test is reliable and valid for the purpose offered, but that it is not affected by common confounding factors. A knowledgeable defense attorney can expose the deficits in HGN's scientific data base and should be well-prepared to challenge misinformation when it is presented in court.

Notes

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