The Best of 2009: Diagnostic Audiology

By Brad A. Stach

The year 2009 was productive for diagnostic articles. I reviewed over 230 articles in the area of diagnostic audiology, the most ever. Including the many good articles described below was, as always, the easy part. Excluding other good ones was painful. But I did so, and here are my picks for the best of 2009.

GREAT FOR THE CLINICIAN

There were some excellent clinical articles, including one by **Rafidah Mazlan** and colleagues in *Ear and Hearing*. Many of us hold to the traditional thinking that acoustic reflexes can't be measured in children younger than 6 months or so. These authors verify more current thinking that reflexes can, in fact, be elicited in infants if a high-frequency probe tone is used. The study they describe confirms the reliability of doing so in a large sample of healthy neonates and adds another tool for assessment in infants.

Most of us think of a notched audiogram as caused by noise exposure, and for good reason. But **David Nondahl** et al., writing in *Ear and Hearing*, remind us that it's not that simple. They compared algorithms for identifying notched audiograms with noise exposure history in patients drawn from a population-based cohort study. They found that many patients with history of noise exposure have notches, but the percentage varies substantially with the algorithm used. They also report that nearly a third of those without a history of noise exposure had notched audiograms.

Most audiologists are seldom called on to evaluate a person's hearing for the purposes of determining fitness for duty. So, if we are suddenly faced with this task, we scramble to find an authoritative source of information on how to do so. **Jennifer Tufts** and colleagues from the University of Connecticut have come to the rescue with an excellent review article, published in the *Journal of the American Academy of Audiology* (*JAAA*). The authors review the functional hearing abilities required to perform hearing-related tasks in jobs such as law enforcement and piloting. They also describe the characteristics and current implementation of auditory fit-for-duty protocols.

Do we really have to torture our patients during caloric testing of vestibular function? Two articles, both from *Ear and Hearing*, suggest that a monothermal caloric screening test is sufficient in many patients, making complete bithermal testing unnecessary. **Guy Lightfoot** and colleagues find that the warm monothermal test has a sensitivity of 95% and that only 29% of patients with normal bithermal tests need to undergo bithermal testing if the monothermal screening is used. Meanwhile, **Owen Murnane** and colleagues show that warm monothermal screening can reduce the need for bithermal tests by 40%. Bring on the warmth.

Another very good clinical article was published by **Jae-Jin Song** and colleagues in *Otology & Neurotology*. They describe results of temporal-bone-computed tomography and audiometric follow-up in a large sample of children with unilateral sensorineural hearing loss. Remarkably, nearly 30% of computed tomography scans were identified as abnormal. Of these, nearly 20% showed bilateral abnormalities. In those who were followed for more than 2 months, over 6% showed hearing sensitivity decline, in some cases bilaterally. The study does an excellent job of demonstrating the need for medical evaluation and continued monitoring of hearing for children with unilateral sensorineural hearing loss.

While there were many first-rate clinical papers over the year, my Best of 2009 in this category is "A Comparison of Presentation Levels to Maximize Word Recognition Scores" by **Lesli Guthrie** and **Carol Mackersie**, published in *JAAA*. Want to get a maximum score without doing a performance-intensity function? Try testing at UCL – 5 dB.

BEST VESTIBULAR SCHWANNOMA READS

Is this a category? Well, it is this year, since *Otology & Neurotology* had a run of interesting articles in 2009 on vestibular schwannomas. One was so good, you'll read about it in my All-Around Favorites. But there were others as well. Most had to do with conservative management of identified tumors—essentially waiting and watching before treating—and the consequences of such management.

Thomas Martin and colleagues describe a retrospective study of 276 patients with vestibular schwannomas who were managed conservatively. Of these, 22% demonstrated tumor growth, with 65% of these growing slowly and the remainder more rapidly. The vast majority of the rapidly growing tumors were detected within 3 years.

Prashant Malhotra and colleagues report on a study of 202 patients with vestibular schwannomas who were also managed by observation. In their group, about 10% were considered to have failed conservative management. Two factors seemed predictive of failure: subjective disequilibrium at presentation and increased tumor size.

So, what happens in the long run to those with tumors that grow during

observation? **Paul Mick** et al. followed 36 patients identified as having tumors that demonstrated growth of greater than 1 mm between consecutive scans. Of those that grew, 64% continued to grow, 30% stayed the same size, and 6% shrank over time.

Okay, so some tumors grow, and some of those keep growing. What are the functional consequences of these changes to hearing? **Willem Godefroy** et al. wrote about 70 patients with vestibular schwannomas that were treated conservatively. Despite a lack of apparent structural changes (63% of tumors did not appear to grow), nearly half the patients showed decreases in hearing.

Why would that happen? An article a few years back from the Massachusetts Eye and Ear Infirmary showed that some tumors have a primary influence on the nerve itself, while others have a secondary influence on cochlear function. **Konstantina Stankovic** and others from that lab continued their work in one of my Bests of 2009 in the vestibular schwannoma category. They examined vestibular schwannoma specimens from 13 patients and divided them into two groups associated with good hearing and with poor hearing. Genetic analysis of the tissue showed a chromosomal region and three other genes from different chromosomes that were significantly different between the two groups of tumors. In other words, tumors with different genetic makeup may have contrasting effects on hearing. Just imagine if these molecular alterations could be targeted therapeutically.

NOT READY FOR PUBMED

We are beginning to see increasing use of wideband reflectance in the measurement of middle ear function, especially in infants. If you are looking for a primer on the topic, check out the article by **Robert Withnell** and colleagues, published in *The Hearing Journal* (*HJ*).

Another review article that I particularly liked is **James Kaltenbach's** excellent summary of tinnitus in *HJ*. He talks about the three components of tinnitus: the acoustic, the attentional, and the emotional, and how they interact. His discussion of central plasticity and the possibility of reversing it is excellent.

I always like *HJ's* Page Ten articles, and I gave one of them my Best of 2009 in this category: "Understanding in noise: Perception vs. performance" by **Gabrielle Saunders**. In a very clear manner, she helps us understand the importance of a patient's misjudgment of hearing ability.

MOST THOUGHT PROVOKING

Noise-induced hearing loss in a population can be predicted using knowledge about the intensity and duration of noise exposure. Imagine if that algorithm could be reversed so that knowledge of the hearing sensitivity in a population could be used to predict the amount of exposure that must have occurred. **Jennifer Tufts** and colleagues did just that in a fascinating article in *Ear and Hearing*. They looked at retrospective data on hearing levels and exposure history of a group of machinists. They then developed a maximum-likelihood fitting procedure in which the noise level input to a standard algorithm was varied to determine the noise level that best accounted for all the data. Oh, just go read the article.

Speaking of noise, I also liked an article by **Robert Davis** et al. in *Ear and Hearing* on the evaluation of complex noise exposure. We are accustomed to thinking of the influence that energy, frequency, and duration of exposure to noise has on hearing. These authors suggest that there's more to the equation. They show that for equivalent energy and spectra, exposure to non-Gaussian noise produced substantially more hearing loss than exposure to Gaussian noise, suggesting that the hazard needs to be redefined based on the complexity of the noise source.

Testing speech recognition in noise sounds simple until you try to design a metric to do it. In an overview article in the *International Journal of Audiology*, **Marianne Theunissen** and colleagues take on the task of describing what is involved in the development and interpretation of tests of sentence recognition in noise. They offer a very thorough discussion of the stimulus, presentation, subject, response, and performance variables.

A lot of thoughts were provoked in 2009, but I had to choose a number one in the *Most-Thought-Provoking* category. And, the winner is **Slavomir Biedron** and colleagues for "On the number of turns in human cochleae," published in *Otology & Neurotology*. You thought you knew this, right? You think there are 2-?, or was that 2-?? I never quite remember. But the authors found that 65% of people had more than 2-? turns and 11% had more than 2-? turns. Now that is thought provoking!

ALL-AROUND FAVORITES

It is becoming increasingly clear that among infants and young children with a diagnosis of auditory neuropathy spectrum disorder some have a sensory hearing loss for which the inner hair cells are to blame and some have a neural disorder in which the auditory nerve is the culprit. It also seems increasingly clear that the two disorders respond differently to conventional amplification/implant treatment. So how can the two be differentiated before treatment is implemented? **Stefan Gräbel** and colleagues report in *Otology & Neurotology* on the use of a non-invasive, objective test of auditory nerve function. They use a ball electrode in the ear canal to provide electrical stimulation to derive a high rate (80/s) auditory steady-state response (ASSR). They found that the steady-state response correlated very well with intraoperative electrically evoked potentials. The exciting implication is that if the EAMFR (evoked amplitude modulated following response) is normal in the absence of an acoustic ABR, the disorder is probably sensory. But if the EAMFR is abnormal in the absence of an acoustic ABR, the disorder is probably neural.

Another of my All-Around Favorites was written by **Robert Turner** and **Annette Hurley** for the *JAAA*. Their idea is that combining tests into a

protocol, a common occurrence in clinical practice, is most often done without a clear understanding of the protocol's performance in testing what it is supposed to test. The authors develop a model for predicting this performance and then apply it to an actual data set of auditory processing tests. The agreement between the predicted and actual data is remarkable.

Old folks don't seem to recognize speech as well as younger ones, even after accounting for differences in hearing loss. But we have not known what neural structures might be responsible for these differences. Writing in *The Journal of Neuroscience*, **Kelly Harris** and colleagues provide us with a glimpse. They had subjects from a younger group and from an older group perform word-recognition tasks in an MRI scanner. The older group had poorer performance in a challenging listening environment than the younger group. The MRI showed group differences in gray matter volume at Heschl's gyrus and the anterior cingulate. So, at least some of the difficulty experienced by older individuals is correlated with structural changes in the auditory cortex.

Here's a question: When is a pure-tone asymmetry significant? You may recall from last year that as many as half of the patients seen in a busy clinic have some degree of asymmetry. Hardly any of them have tumors. So what do you use as a criterion for significant asymmetry? And why? You don't know, do you? Well, **Issam Salib** and colleagues do. In *Otology & Neurotology,* they describe a study that compared risk factors and clinical data in a group of patients with vestibular schwannoma and a control group without vestibular schwannoma. Results suggest that asymmetry in pure-tone thresholds at 3000 Hz is the best predictor of group placement. They conclude by proposing "Rule 3000," which states that an asymmetry of 15 dB or more at 3000 Hz is a positive indicator of retrocochlear disorder.

We have all heard dire predictions about the approaching baby boomer bubble and how it will swamp our clinics with presbyacusic patients pining for our scarce expertise. What if, on the other hand, the seemingly much healthier boomers, with an ever-increasing life expectancy, also have healthier hearing than past generations? **Weihai Zhan** and colleagues published an intriguing article in the *American Journal of Epidemiology* in 2010 (it appeared online in 2009 and I read it in 2009, so I'm including it as a Best of 2009). The authors assessed the effect of birth cohort on prevalence of hearing loss across an age range from 45 to 94 years. Their results showed that with every 5-year increase in birth year, the odds of having hearing loss were 13% lower in men and 6% lower in women. It appears that older adults today have good hearing longer than previous generations, bursting the bubble as it were.

And now, for the **Best of 2009** in the *All-Around Favorites* category: "Newborn hearing screening speeds diagnosis and access to intervention by 20-25 months." Written by **Yvonne Sininger** and colleagues and published in *JAAA*, it's my favorite because of the importance of demonstrating that newborn hearing screening works. The staggered onset of screening programs in California enabled the authors to gather data on children with hearing loss from one group that was screened and from one group that went unscreened. Children who had been screened were diagnosed 25 months earlier, fitted with hearing aids 24 months earlier, and enrolled in intervention programs 20 months earlier than those who were not screened. Case closed. This was truly a Best of 2009.

ARTICLES CITED

Biedron S, Westhofen M, Ilgner J: On the number of turns in human cochleae. *Otol Neurotol* 30:414-417.

Davis RI, Qiu W, Hamernik RP: Role of the kurtosis statistic in evaluating complex noise exposures for the protection of hearing. *Ear Hear* 30:628-634.

Godefroy WP, Kaptein AA, Vogel JJ, van der Mey AGL: Conservative treatment of vestibular schwannoma: A follow-up study on clinical and quality-of-life outcome. *Otol Neurotol* 30:968-974.

Gräbel S, Hirschfelder A, Scheiber C, Olze H: Evaluation of a novel, noninvasive, objective test of auditory nerve function in cochlear implant candidates. *Otol Neurotol* 30:716-724.

Guthrie LA, Mackersie CL: A comparison of presentation levels to maximize word recognition scores. *JAAA* 20:381-390.

Harris KC, Dubno JR, Keren NI, Ahlstrom JB, Eckert MA: Speech recognition in younger and older adults: A dependency on low-level auditory cortex. *J Neurosci* 29:6078-6087.

Kaltenbach JA: Insights on the origin of tinnitus: an overview of recent research. *Hear J* 62(10):28-31.

Lightfoot G, Barker F, Belcher K, Kennedy V, Nassar G, Tweedy F: The derivation of optimum criteria for use in the monothermal caloric screening test. *Ear Hear* 30:54-62.

Malhotra PS, Sharma P, Fishman MA, Grumbine FL, Tholey R, et al.: Clinical, radiographic, and audiometric predictors in conservative management of vestibular schwannoma. *Otol Neurotol* 30:507-514.

Martin TPC, Senthil L, Chavda SV, Walsh R, Irving RM: A protocol for the conservative management of vestibular schwannomas. *Otol Neurotol* 30: 381-385.

Mazlan R, Kei J, Hickson L: Test-retest reliability of the acoustic stapedial reflex test in healthy neonates. *Ear Hear* 30:295-301.

Mick P, Westerberg BD, Ngo R, Akagami R: Growing vestibular schwannomas: What happens next? *Otol Neurotol* 30:101-104.

Murnane OD, Akin FW, Lynn SG, Cyr DG: Monothermal caloric screening test performance: A relative operating characteristic curve analysis. *Ear Hear* 30:313-319.

Nondahl DM, Shi X, Cruikshanks KJ, Dalton DS, Tweed TS, et al.: Notched audiograms and noise exposure history in older adults. *Ear Hear* 30:696-703.

Saliba I, Martineau G, Chagnon M: Asymmetric hearing loss: Rule 3000 for screening vestibular schwannoma. *Otol Neurotol* 30:515-521.

Saunders GH: Understanding in noise: Perception vs. performance. *Hear J* 62(10):10-16.

Sininger YS, Martinez A, Eisenberg L, Christensen E, Grimes A, Hu J: Newborn hearing screening speeds diagnosis and access to intervention by 20-25 months. *JAAA* 20:49-57.

Song JJ, Choi HG, Oh SH, Chang SO, Kim CS, Lee JH: Unilateral sensorineural hearing loss in children: The importance of temporal bone computed tomography and audiometric follow-up. *Otol Neurotol* 30:604-608.

Stankovic KM, Mrugala MM, Martuza RL, Silver M, Betensky RA, et al.: Genetic determinants of hearing loss associated with vestibular schwannomas. *Otol Neurotol* 30:661-667.

Theunissen M, Swanepoel DW, Hanekom J: Sentence recognition in noise: variables in compilation and interpretation. *IJA* 48:743-757.

Tufts JB, Vasi KA, Briggs S: Auditory fitness for duty: A review. *JAAA* 20:539-557.

Tufts JB, Weathersby PK, Marshall L: Estimation of equivalent noise exposure level using hearing threshold levels of a population. *Ear Hear* 30:287-290.

Turner RG, Hurley A: Evaluating a model to predict protocol performance. *JAAA* 20:644-651.

Withnell RH, Parent P, Jeng PS, Allen JB: Using wideband reflectance to measure the impedance of the middle ear. *Hear J* 62(10):36,38,40-41.

Zhan W, Cruickshanks KJ, Klein BE, Klein R, Huang GH, et al: Generational differences in the prevalence of hearing impairment in older adults. *Am J Epidemiol* 201;171:260-266.