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CASE STUDY

VOCAL FOLDS

VISION RESEARCH HIGH-SPEED DIGITAL CAMERAS FACILITATE REVOLUTIONARY RESEARCH INTO DIAGNOSING VOICE DISORDERS

Dr. Dimitar Deliyski in the Voice and Speech Lab at the University of South Carolina

WHEN IT'S TOO FAST TO SEE, AND TOO IMPORTANT NOT TO®

Take a moment to think of the impact that losing your voice could have on your life. It could ruin your career, especially if you rely on your voice like a singer or broadcaster does, or make life terribly difficult as far as simple communication between friends and family is concerned. Unfortunately, according to the *National Institute on Deafness and Other Communication Disorders*, approximately **7.5 million** Americans have trouble using their voices and are facing this frightening prospect today.

Voice disorders are a widespread problem and much is still left to be learned. Several organizations exist to help raise awareness about the issue and a host of scientists and researchers are dedicated to uncovering the mysteries of the human voice, including Dr. Dimitar Deliyski, a renowned researcher at the *University of South Carolina's Arnold School of Public Health*. Committed to advancing the scientific understanding of the human voice, Dr. Deliyski has recently embarked on a five-year study to develop a new methodology to help diagnose voice disorders and to advance the basic science of understanding voice. The research is supported by a $3.1 million RO1 grant from the *National Institute on Deafness and Other Communication Disorders*.

With the help of Vision Research, a leading manufacturer of high-speed digital imaging solutions, Dr. Deliyski will explore the movements of the human vocal folds using a revolutionary procedure known as laryngeal high-speed video-

"Many people might take their voices for granted – until suddenly they are deprived of the power of speech."

- Walter Cronkite

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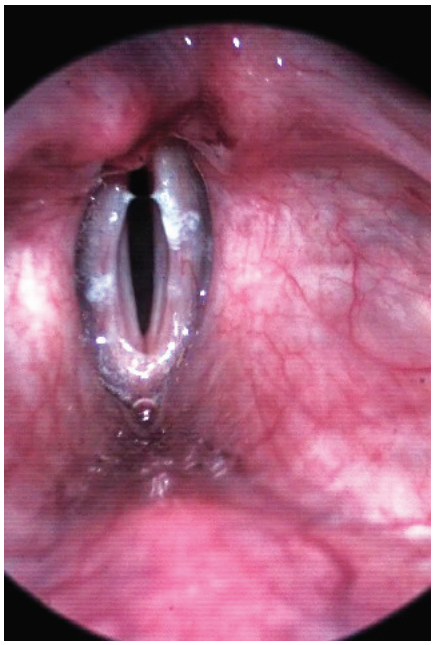

Vocal folds of a man sustaining the vowel i, captured at 4000 pictures-per-second

"High intensity lighting could very well damage the vocal folds we are attempting to study, so the camera must have very high sensitivity and require as little light as possible."

- Dr. Dimitar Deliyski

endoscopy (HSV). Through the use of HSV, Dr. Deliyski will be able to analyze and capture the motions of human vocal folds as they vibrate to produce sound. Due to the fact that human vocal folds vibrate at considerable speeds – sometimes upwards of 1,000 times per second – Dr. Deliyski required a high-speed digital camera that was as unique and revolutionary as the project that he was spear-heading. It was essential to the success of the research that the high-speed digital camera employed boasted an impressive marriage of features, including high-sensitivity, bit-depth, resolution and speed, and for this Dr. Deliyski turned to Vision Research.

To date, the prevailing method for researching the movements of human vocal folds is laryngeal videostroboscopy. By using an endoscope fixed with a standard video camera, and a strobe light set to flash once during each video frame throughout the vibration cycle of a patient's vocal folds (via electronic pitch synchronization), researchers are able to reproduce the effects of slow motion. Although it's a useful tool and has undoubtedly improved the diagnosis and treatment of voice disorders, videostroboscopy has a number of significant limitations.

"Since its introduction, videostroboscopy has had tremendous clinical success and is now considered the 'gold standard' in laryngeal imaging," said Dr. Deliyski. "However, due to basic stroboscopic principles and the nature and behavior of human vocal folds, the technology has its limitations, especially for the visual evaluation of human vocal folds. Stroboscopy simply cannot capture the *true* cycle-to-cycle vibratory behavior of the vocal folds, and as a result, the intra-cycle vibration seen in stroboscopy displays an illusory 'slow motion.' Furthermore, stroboscopy has no benefit to persons whose voice disorder causes irregular vocal fold vibration, as the stroboscopic images produced can not be used to accurately to diagnose disorders. This would affect approximately half of patients with voice disorders."

With the help of Vision Research, Dr. Deliyski was able to identify the ideal high-speed digital camera for the task, specifically one that would be able to perform in the unique environment in which it would be used. For his study, Dr. Deliyski chose the Vision Research Phantom v7.3 digital camera, to serve as the most critical component for his HSV research. By incorporating the v7.3, Dr. Deliyski was able to take his research to a whole new level, with the capability of recording vocal folds in real time, at an astonishing speed of 6,668 pictures-per-second (pps) at a full resolution of 800 x 600 pixels. For even more impressive video, Dr. Deliyski also records at 16,000 pps by reducing the Phantom v7.3's resolution to 320 x 320 pixels. Equipped with a 70° rigid endoscope and 300W constant Xenon light source, the v7.3 allowed Dr. Deliyski to analyze the human vocal folds in ways never before possible, helping usher in a new era for laryngeal HSV.

The Phantom v7.3 high-speed digital camera in the Voice and Swallowing Center's clinic at Charlotte Eye Ear Nose and Throat Associates in North Carolina.

"There are a number of factors that are critical in HSV, but paramount is the sensitivity of the high-speed digital camera's CMOS sensor," noted Dr. Deliyski. "High intensity lighting could very well damage the vocal folds we are attempting to study, so the camera must have very high sensitivity and require as little light as possible. The proprietary Vision Research CMOS embedded in the Phantom v7.3 yielded the performance that this project required. The extraordinary performance of the v7.3'ssensor allowed our team to accurately record exceptionally rich detail that was never before available with previous stroboscopic or HSV systems."

In addition to this newly integrated HSV system, Dr. Deliyski's team is developing a whole new methodology for the analysis and clinical interpretation of the acquired images. The analyses include those that allow presenting the visual information that is hidden to the eye in a new and more intuitive way to the clinicians, and those that are fully automated, in which the results of the exam are presented in a quantitatively comparable form. The speed, spatial resolution and image quality of the recordings is critical for the accurate analysis of the human vocal folds.

When it comes to HSV, color and spatial resolution are very important when identifying lesions, vascularities and tissue changes, as well as for accurately representing the edges of the vocal folds. Spatial resolution is also important to allow for a wide view angle necessary to examine the full anterior-posterior view of the vocal folds and their surrounding anatomic structures. The temporal resolution of a high-speed digital camera is essential for accurately displaying the mucosal wave produced by the vibration of the vocal folds and providing sharp edges, especially when viewing high-pitched samples.

Although it requires a significant amount of memory, long sample duration is necessary to register multiple phonations in a continuous recording, including comfortable, high and low pitches, glides, loudness levels, repetitive phonations, and forced inhalation. High dynamic range, like that of the Phantom v7.3's 14-bit grayscale /42-bit RGB CMOS sensor, allows for improved viewing quality and increased accuracy of automated image analyses.

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While much work and discovery remains, Dr. Deliyski and his team are hopeful for the future of HSV and that it will ultimately supplant stroboscopy as the 'gold standard' clinical technique for laryngeal imaging. Not only does HSV possess all the useful features of videostroboscopy, it overcomes the method's shortcomings and provides new, revolutionary features for more accurate objective and quantification measurements.

This new technology featuring the Phantom camera has been already implemented at two clinical sites. At the Center for *Laryngeal Surgery and Voice Rehabilitation, Massachusetts General Hospital*, Boston, M.A., the HSV system became an important component in assessing voice function for patients treated with a revolutionary new laser technique for treating laryngeal cancer developed by Drs. Steven Zeitels and Robert Hillman. At the *Voice and Swallowing Center, Charlotte Eye Ear Nose and Throat Associates*, Charlotte, N.C., HSV is being tested as part of the day-to-day clinical voice evaluation practice by Dr. Terri Gerlach.

"Our goal is to develop HSV into a robust tool that will provide further insights into the biomechanics of laryngeal sound production, as well as enable more accurate functional assessment of the pathophysiology of voice disorders. Essentially the heart of our HSV system, the Vision Research Phantom brings a level of performance and reliability that continues to open new doors for our research, ultimately leading to refinements in the diagnosis and management of vocal fold pathology."

Phantom v7.3 high speed digital cameras facilitate revolutionary research into diagnosing voice and speech disorder

To view sample clips of human vocal folds captured in slow motion with the Phantom v7.3, please click the following link -
www.visionresearch.com/go/vocal

The clips were provided by the Voice and Speech Lab, University of South Carolina, Columbia, S.C.,

www.sph.sc.edu/facultystaffpages/facstaffdetails.php?ID=317

and the MGH Center for Laryngeal Surgery and Voice Rehabilitation, Boston, M.A.,

www.massgeneral.org/voicecenter/about/

About Vision Research:

Vision Research designs and manufactures high-speed digital imaging systems used in applications including defense, automotive, engineering, science, medical research, industrial manufacturing and packaging, sports and entertainment, and digital cinematography for television and movie production.

The Wayne, N.J.-based company prides itself on the sensitivity, high-resolution and image quality produced by its systems, robust software interfaces, and reliability and versatility of its camera family – all which continue to stand as benchmarks for the high speed digital imaging industry.

Vision Research digital high-speed cameras add a new dimension to the sense of sight, allowing the user to see details of an event *when it's too fast to see, and too important not to®*. For additional information regarding Vision Research, please visit *www.visionresearch.com*.

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