Building caption... (Inset) Participants at the 1953 ICO at the Instituto de Optica.

Visual Optics Research in Spain: A Historical Perspective

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Spain is a world leader in physiological optics and vision applications—thanks to a history of pioneering research that extends more than half a century.

Spain is home to some of the world's most well-regarded and productive research groups in visual optics. Their work is published in prestigious international journals, receives numerous citations, and has been translated into numerous clinical and industrial applications. Spurred by these achievements, the field has expanded exponentially over the past few years.

As important as Spain's recent accomplishments are, however, they would not have been possible without the groundbreaking contributions of early pioneers, beginning in the 1940s with Otero, Durán, Plaza, Aguilar and others.

The 1940s and 1950s: Otero and night myopia

Spain's history of research in visual optics is inarguably linked to Jose M. Otero and his pioneering studies of night myopia. Otero was a military engineer who trained at the Institute of Optics in Berlin under Franz Weidert. Upon returning to Spain in 1934, he began work at the Navy Optics Laboratory, where he focused on optical element design. He soon joined the Rockefeller Institute of Physics and Chemistry of the "Junta para Ampliación de Estudios" (a primary research institution in Spain, first presided by Nobel laureate Ramón y Cajal). Five years later, Otero chaired the optical section (which was afterwards called the "Institute of Optics") of the "Consejo Superior de Investigaciones Científicas."

Otero recruited a lively group of young researchers, including Armando Durán, Piedad de la Cierva, Jiménez Landi, Maruja Egües and Lorenzo Plaza, who were well trained in geometrical optics, optical materials or colorimetry (some of them at the National Bureau of Standards in the United States). In the early 1940s, the group started working on a project to design optical components for periscopes in submarines and binoculars. They conducted measurements of visual performance—visual acuity, chromatic aberration and luminous efficiency—with the new instruments under low illumination and found a systematic myopic shift (of 1.25 D) in night conditions.

The group reported their results in the Spanish journal *Anales de Física y Química* in 1941 and later in the *Journal of the Optical Society of America*. They also presented their work at invited lectures throughout the world, helping to keep research active. A Ph.D. thesis by Durán, Cabello, Casero, Carro and Plaza advanced the understanding of the causes of night myopia and related phenomena, stating that the eye experienced a change in its accommodation mechanism in the absence of stimuli.

In the early 1950s, the Instituto de Optica moved to a new building. The department of vision, which was

headed by Otero, was divided into three subsections: photometry and color (led by Plaza), physiological optics (Aguilar) and ocular examination (López Enríquez).

In 1953, a colloquium was organized to address the problems of vision as part of the International Commission for Optics conference (ICO3). In that meeting, Yves Le Grand, W.S. Stiles and R. Granit y C. Wald (later Nobel laureates) gave invited lectures on binocular vision, threshold sensitivity, chromatic vision and the chemical basis of vision. Among others participants, A. Arnulf, F. Campbell, F. Flammant, R.A. Weale, W. Wright. G. Toraldo, M. Ivanoff and B. O'Brian presented contributions together with the Spanish researchers. In subsequent years, research had expanded to other areas, such as the sensitivity of photoreceptors (with a seminal paper by Aguilar & Stiles), binocular interaction and electrophysiology.

The 1970s and 1980s: A new renaissance

In the early 1970s, Lorenzo Plaza, director of the Institute of Optics, hired Albert Arnulf after his retirement in France. Arnulf was one of the most influential vision scientists of the mid-20th century. Two young graduates moved from the University of Zaragoza (Javier Santamaría and Julián Bescós) to the Instituto de Optica in Madrid to be trained in ocular optics and collaborate with Arnulf. They built a series of experimental devices to study the microfluctuations of the accommodation based on imaging the crystalline lens by using the Foucault technique in two dimensions (Toepler) with annular apertures.

Although they obtained nice pictures of the lens shadows, the technique was too complicated and the data too difficult to evaluate. Arnulf suggested analyzing the microfluctuations of the accommodation by directly recording the double-pass retinal image of a point source after reflection in the retina—a technique he had already used in France with a line source. The team decided to use a laser point and an image intensifier device and obtained for the first time a dynamic recording of the double-pass retinal images in the living eye.

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This series of experiments was the precursor to many of today's activities in experimental visual optics around the world. As Spain progressed socially and economically through the late 1970s, research into visual optics research flourished as well. Indeed, the number of papers with Spanish authors that were published in JOSA (and the A series after 1984) has risen nearly exponentially from the 1940s to the present.

It is certainly impressive to discover that the groundbreaking results published in JOSA in the 1940s still reflect current hot topics in the field, including the spherical aberration of the eye or cone-photoreceptor directionality.

Spanish researchers in visual optics have much reason to thank their predecessors. Today, they can take for granted their role in high-level conferences, research visits from world-class scientists and Nobel laureates, and high-level educational opportunities. Hopefully, the tradition of excellence will continue for many generations to come. ◭

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