Tributes and Remembrances of IU Professor Emeritus Irvin M. Borish
A Survey on Parental Knowledge of Pediatric Vision Care
A Report on Visual Discomfort Associated with Viewing 3D Media
Convergence Accommodation to Convergence (CA/C) Ratios:
A Potential Clinical Diagnostic Tool
The year 2012 saw the passing of the optometric giant that the readers of Review of Optometry voted the most influential optometrist of our time, Irvin M. Borish. A number of writers have contributed their thoughts on the legacy and contributions of former IU professor Borish. Next, a survey of parents on their knowledge of pediatric vision care shows that we as optometrists should be doing a better job of educating the public about vision care for infants and young children. Visual discomfort from 3D movies and media is fairly common. One of our articles addresses that matter. And lastly, a short theoretical review gives an overview of studies on CA/C ratios.
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Remembering Dr. Irvin Borish
John F. Amos, O.D., M.S.

I first met Dr. Borish in 1969 when I was a new graduate student in the Physiological Optics Program at Indiana University. It was during this time that Dr. Borish drove to Bloomington one day a week to teach a course on clinical optometry in the professional program of the IU Division of Optometry. I was, of course, familiar with Dr. Borish by reputation, because I had studied using his book Clinical Refraction, as an optometry student at Illinois College of Optometry. As soon as I met Irv, I was impressed by his breadth of clinical optometry knowledge and his unbounded energy and enthusiasm. This opinion did not change during the more than 40 years I knew him.

We had numerous conversations on a wide variety of topics over these years and, it was during this time, I realized what a wealth of information he possessed regarding the history of optometry. I remember him recounting his years on faculty of the Northern Illinois College of Optometry (NICO) and the many challenges facing the institution and profession during these formative years. He would also discuss his relationship with Drs. Sheard, Fry and other faculty at The Ohio State University as they sought to gain separate college status and begin a graduate program among other issues.

Dr. Borish possessed a remarkable memory and it seemed as though he could recall every detail of each meeting he attended. Some of his best recollections were related to the many trials and tribulations Indiana optometrists experienced in establishing the optometry program at IU. Fortunately this period of optometric history and, indeed the entire life of Dr. Borish, have been preserved by Dr. William Baldwin in his book Borish. The challenges the optometrists of this time period encountered were significant and constant as they attempted to move the profession forward.

Dr. Borish was kind enough to write a Foreword for a book I had written about the diagnosis and management of vision care problems. His remarkable insight captured the essence of the book and I was pleased and grateful he had agreed to accept my request. He was always willing to serve the profession and perhaps served on more committees or task forces during his long and productive life than any other optometrist.

From the perspective of a two year professional education the changes in the profession witnessed by Dr. Borish, over his lifetime, were phenomenal. He had begun his optometric education in January 1932 and graduated in January 1934. After a short time in private practice, he began, in 1936, his career in optometric education. This career continued, in one form or the other, until he retired in 1989 from the University of Houston. Even in retirement he continued to make periodic visits to schools and colleges of optometry.

Dr. Borish not only witnessed the metamorphosis of the profession but played a significant role in its educational and organizational growth and evolution for more than seven decades. Perhaps his most enduring legacy is his iconic book Clinical Refraction. This book had its beginnings as the course syllabus for his clinical optometry course in 1938. He revised and edited subsequent editions from 1949 until 1975. This book informed every optometrist in some manner for many decades.

I will always treasure the fond memories I have of the man who contributed so much to the professional lives of so many.

John F. Amos is former Dean of the University of Alabama Birmingham School of Optometry and a former president of the Association of Schools and Colleges of Optometry.

In Memoriam: ICO Remembers Irvin Borish
Arol Augsburger, O.D., M.S.

Irvin Borish, O.D., D.O.S., a distinguished Illinois College of Optometry alumnus, often considered “the
father of modern optometry,” died March 3, 2012 in Florida at age 99. Dr. Borish graduated from the Northern Illinois College of Optometry, a predecessor of ICO, in 1934. He served on the school’s faculty for eight years, including as clinic chief of staff and assistant dean. Following his service to ICO, he established a private practice in Kokomo, Indiana, and had a distinguished career in optometric education at Indiana University and University of Houston.

Dr. Borish’s influence has been felt at ICO and every other optometry school in the nation for decades. Among his many accomplishments, he authored several textbooks, including the much-used Clinical Refraction, and was granted five patents for contact lenses, including bifocal contacts. He was a founding member of the Indiana Chapter of the American Academy of Optometry, and was president of the Indiana Optometric Association and editor of its journal. His extraordinary career and achievements have benefited optometrists everywhere.

My tribute to Irvin M. Borish

By the request of the editor, I am taking this opportunity to offer my tributes and recollections of one of American optometry’s finest, Dr. Irvin M. Borish. While Dr. Borish’s accomplishments and acknowledgements have been many, I want to direct my attention to one aspect of his character that I was privileged to observe over many years; that is, his love for optometry students.

My first remembrance of Dr. Borish goes to the period I was an optometry student at IU in the latter part of the 1960s, when he would visit campus and give lectures to the students. I can still visualize the day he spoke to my class about how to deliver an efficient eye and vision examination.

After ten years of private practice in Charlotte, North Carolina, I joined the faculty at the University of Houston College of Optometry (UHCO) in 1981. After Dr. Borish retired as an optometric practitioner and professor at Indiana, he joined the faculty at UHCO in 1982, being appointed to the Benedict Chair. Yes, I got to be around this great man for encouragement and guidance for many more years. Even after he retired to Florida from UHCO years later, he would come back to give a lecture to the students in the Community Health Optometry class, for which I became course master in 1994. He very capably spoke on both the history and future of our profession. About five years ago, I asked his permission to have his lecture video recorded. His reply was a question “Does this mean you will not need to invite me in the future?” My reply was that so long as I was the course master for the course, he would be invited every year. I held true to my promise and he gave his last lecture to that class at the age of 97 in 2010, the year of my retirement. You could tell he loved speaking to the students. He always ended his lecture by challenging the class to carry on the development and advancement of optometry when the time came for them to assume leadership from their predecessors. Every year students would bring their cameras and ask for photos with him. What a man! What an optometrist!

Eulogy for Dr. Irvin M. Borish, Sunday, March 11, 2012, Edgewater Pointe Estates, Boca Raton, Florida

William J. Benjamin, O.D., Ph.D.

It was a short 28 years ago when I first met Irv Borish. Not long after, my wife and I accompanied him and Bea on a trip to Britain, where we happened upon a house in which had lived Charles Dickens. You will all recognize the phrase in Dickens’ book, A Tale of Two Cities, that began, “It was the best of times, it was the worst of times, …” I don’t have to remind this audience that Irv Borish never saw things as the worst of times. He had gone through such a period in his youth but never spoke about it in that fashion. He always saw the opportunity to improve things. He envisioned and engendered only the best of times.

A young Irv Borish took from Charles Sheard an interest in developing Optometry as a learned profession. This interest continued with the cooperation of Glenn Fry at Ohio State University and others such as Norm Haffner.
It was 1984 when I was assigned a room across the hall from Irv. Never in my lifetime will such a lucky event again occur. The assignment was made by my Dean, Bill Baldwin, and I now more than suspect a shrewd calculation in that selection. Thus situated, I saw how Irv operated; how he prepared a person to take on an idea that he introduced. He would often start with a story that had a meaning related to the conclusion that he later wanted the person to reach. Then he would wait until the idea took hold. He waited sometimes for months, even years. He waited so long that the person would eventually lose track of where the idea came from, and began to think that he, the person, had thought of the idea himself!

Irv didn’t care that the idea was not attributed to Irv. Irv just wanted that person to take on the idea. He delighted in creating a convert who believed that the idea was that of the convert – not Irv’s! In my estimation, this is why Irv was so successful in getting his ideas considered and accepted. He didn’t care so much to take credit for an idea. He didn’t push to change a person’s opinion immediately. He waited, and he let nature take its course. He’d rather have converts who felt that they had conceived of the ideas, themselves, and who then went out to spread the ideas by themselves.

On an even more personal note, as I was a young faculty member, Irv had my back, and he afforded me opportunities if I could but just grasp them. Some of them I did, and others … well, I tried! Irv told me that he had a daughter, Fran, and that Sarita was like a second daughter, but that he had never had a son. I believe he thought of me like a son that he never had.

Before coming here today, I received messages from all over the world. It seems like the entire faculty of the UAB School of Optometry sent me emails, as did the membership of the International Society of Contact Lens Specialists, of which Irv was a member; Dr. Harold Davis of Chicago; Dr. John Classé of Birmingham; Maria Voce, our coordinator of Clinical Eye Research at UAB; and Ann Goodrich, my assistant at the University of Houston, who now resides in Dripping Springs, Texas. These are but a smattering of how far and wide the Borish influence is felt. They wish to convey their deepest sympathy, and to Irv, if he is watching, and I think he is, their final salutations.

It is Irv’s great legacy to have passed his knowledge to all eye care practitioners, and his philosophy to many. Most of those who received fortified doses of his philosophy are in attendance today. You are the ones who will scatter his legacy forward and shall in his honor dedicate yourselves to continuing his great task. He fostered our ability to do so over a lifetime of 99 years, and gave us the full measure of his devotion. This is, the far, far better thing that he had done, as Dickens might say, that prepared us for that day, 8 days ago, when he departed to a far, far better place than even he had known.

Dr. William J. “Joe” Benjamin is editor, Borish’s Clinical Refraction, and a professor at University of Alabama at Birmingham School of Optometry.

Another Side of Irv Borish
Irving Bennett, O.D.

To most optometrists, Irv Borish was an academic, a scientist, a prolific painter, an author and lecturer, and, of course, an outspoken champion of good causes. Yes, he was all of those; and he was something else. Irv Borish was a practice management enthusiast and “businessman” and did both of these with ease and enthusiasm.

Let me explain. Way back nearly 50 years ago, I had the good fortune to learn about a lens introduced in France that featured a smooth transition between its distance formula and its near power. A commercially “acceptable” progressive lens had been created by Optical Engineer Bernard Maitenaz and was not yet available on the international market. Called Varilux, the lens was soon to be introduced in the USA. I was consulted to see how this could best be done successfully since it was no secret that Varilux had a very narrow transition zone and an inordinate amount of distortion in its 14 millimeter transition periphery.

I suggested to the leaders of Essel, the forerunner company of today’s Essilor, that American optometrists would be skeptical about prescribing a lens with so much distortion unless they were assured by the academic community that the lens would be “consumer-acceptable.” I promptly suggested that Dr. Irvin Borish, then teaching at the Indiana University School of Optometry, be contacted to do a double blind study among Varilux, standard flattop bifocals, and the
Ultravue lens, also a progressive that was being introduced on the American market.

A conference was held in Pittsburgh between Dr. Borish and Marc Alexandre of Essel and an “agreement” was developed. No surprise (to me at least) but Borish was not interested in being paid for his study. An ethical and moral person, Irv was not willing to be a hired gun. He said he would do the study with patients and regardless of the results, that is be they good or be they bad for Varilux, he would publish what he found. It was well known that in the USA pharmaceutical companies often commission studies of products but they maintain the rights to the results and publish only those papers that they feel they want in the public view. Not so with Irv Borish.

The rest of the story is well known history. The double blind study showed that patients could adapt to the small channeled Varilux lens but even more important the study’s participants showed an overwhelming preference for the Varilux progressive over flattop bifocals and the Ultravue lens. It was the results of this study that propelled the Varilux introduction in the United States and put progressive addition lenses on track to capture the presbyopic market!

Rightfully the story would end here. Researcher Borish published his study’s results and returned to his desk at Indiana University teaching students the whys and wherefores of eye examinations. But that was only partially the case.

About this time, I was running a small company called Advisory Enterprises. It published four national ophthalmic magazines including Optometry Management and it sponsored Optifair, a national ophthalmic conference/exhibition. To support these activities, Advisory Enterprises did considerable data collection on optometric practice. Irv Borish was fascinated with the data we were producing and he used those data for his innumerable practice management articles and lectures.

Irv Borish combined practice management information in his worldwide tours explaining progressive lenses by pointing to them as vehicles to enhance the private practice of the profession. He often confided in me that progressive lenses, sold primarily in the early years to private optometrists and ophthalmologists, deserved some credit for the economic stability of the profession of optometry.

Jacques Stoerr, former President of Essilor America, once told me that “basic common sense and an acute sense of observation combined with the strong knowledge in his background was what made Dr. Borish the brilliant person he was.”

I could not have said it better.

Irving Bennett, practiced for many years in Pennsylvania. He is former editor of the Journal of the American Optometric Association and the founder of Optometric Management magazine.

Thoughts of Irv Borish
Jay M. Enoch, O.D., Ph.D.

Irv Borish was an original! He was a friend, a mentor, and a sublime teacher and guide, and much more to so many of us in optometry. He was a gentle, affectionate, caring man. Irv has been at the center of our profession of optometry for much of my lengthy career; and I have always looked up to him as guide, teacher, friend, soulmate, and more. That is, he has been central to the practice and teaching of optometry for decades! He has set the pace and tone of this profession seemingly forever. His timely and learned text has become a/the teaching standard in our schools, and he has represented us well and consistently. He was a man for all seasons for the optometric profession! We owe him our gratitude in all things! And he was truly a very decent person!!

Jay Enoch, one of optometry’s leading research scientists, is former Dean of the University of California Berkeley School of Optometry.

Eulogy Presented March 11, 2012
Alden N. Haffner, O.D., Ph.D.

Reverend clergy, members of the Borish family, colleagues and friends who adored and respected Dr. Irvin M. Borish: All of the obituary notices that have been published, or those that will be published, bear the cold accuracy of facts assembled to describe and chronicle Dr. Borish’s long and enormously productive life. And the facts of his lifetime activities are, without doubt, impressive and inspiring. But, I will not repeat
them at this memorial service this afternoon. In fact, there are, in my view, much larger meanings than the recitation of the facts of his life.

I last spoke to Irv about three weeks before he died, and well after his 99th birthday. He pointedly reminded me that I traveled to Boca Raton for his 95th birthday celebration and that I addressed the happy crowd at that event. He then asked (it sounded more like a directive) me to prepare two presentations – one to celebrate his 100th birthday and the other his eulogy. I made a commitment to do both. Regrettably, only one will do.

After all of the details of his eventful life are read, and their meanings absorbed, 3 facets stand out. The first, and most significant, is that he gave scientific and professional legitimacy to our profession, optometry. For many decades since its initial publication, Clinical Refraction by Borish was the fundamental text that unified optometric practitioners throughout the United States and, moreover, in a host of countries throughout the world. It was used as the standard text, and it brought philosophical-scientific unity to optometry. This was, in my view, a monumental achievement. Its impact on optometry cannot be judged as anything less than fundamental and progressive.

Irv was, throughout his career, deeply concerned about the education of optometrists. Indeed, in his lifetime, he was intimately involved in the affairs of three major institutions: the Illinois College of Optometry, the Indiana University School of Optometry, and the University of Houston College of Optometry. The force of his intellect and the force of his personality, both awesome, influenced the leadership of those splendid houses of learning. He urged, cajoled, argued, persuaded, and ultimately, convinced the respective leadership groups that scientific standards should be under constant review in pedagogy. As a person who spent 35 years in a great university, I can attest that Irv Borish’s institutional contribution was to pull optometric education away from vocational education and forcefully to advocate for professional education as the model for our discipline. This contribution was incalculable in importance; that he did so much of this while still engaged in private practice (Kokomo, Indiana) bespeaks the expenditure of enormous personal energies. Irv’s commitment was total and unflagging.

In the next few months, many colleagues in our profession will come forward with personal stories about their encounters with Irv. They will all be different, but, many, remarkably the same. His abiding humanity, his ability always to be the teacher, his profound love for his profession, and his thirst for current knowledge about “what’s going on” were hallmarks of his dynamic personality. But, I have a different, and very personal, story to recount. In the mid-1970s, the American Academy of Optometry was holding its annual meeting at the Waldorf-Astoria Hotel in New York City. On a Sunday morning, I was delivering a paper on public health. While speaking, Dr. William Baldwin came running down the aisle and interrupted my presentation while shouting at me, “Irv is very ill. Come at once.” After turning my paper over to the moderator to complete its reading, I raced with Bill to Irv’s room. Of course, Bea, his loving, devoted (and very tolerant) wife, and partner to more than 60 years, was in a state of anxiety about Irv’s physical distress. (In fact, he was in the midst of a massive coronary dysfunction) I immediately telephoned my personal internist/cardiologist, Dr. Jerome Schack. Luck was with us because I reached him at Beth Israel Medical Center where he was making rounds.

He advised that we dress Irv warmly, secure a taxicab, and he would meet us in the hospital. Bea, Irv, and I arrived at the hospital within 20 minutes, and Jerry Schack saw him immediately. I sat with Bea until we were notified that Irv promptly was moved to the Cardiac Intensive Care Unit. The seriousness of his illness, and the complications that ensued, required more than a month’s hospital stay. Bea stayed with me at my home, though there were daily hospital visits. Naturally, Irv was frequently conducting seminars with the hospital staff on all sorts of subjects. When he was finally on the mend and discharged, he joined Bea in my home for about 10 days until he was given permission to fly home to Indiana.

About a month later, Bea and Irv called me (though we spoke frequently after their return home) to tell me that they wanted to get me a gift as a token of their appreciation. I resoundingly refused, which provoked a prolonged argument. A few days later, Irv called me to say that he was going to execute a painting (he was a prolific artist), and that he and Bea had fixed on that idea. I (graciously) accepted the offer.

About 6 months passed and, one day, the painting arrived. It was a beautiful watercolor of the skyline of lower Manhattan viewed from the Hudson River. But
there was something very curious about the skyline. The World Trade Center twin towers were “broken” and incomplete at the top. When I asked about the towers, Irv’s response was, “well, I saw it that way.” The painting, mounted and framed, still hangs in my study.

The September 11th tragedy, some 35 years after the painting’s creation, served as an eerie and stunning surprise. There still is some mystery about Irv’s conception. The Essilor Company published a book of Irv Borish’s artistic work. The painting of the Manhattan skyline with the broken towers introduced the publication. While Indiana University and the University of Houston have asked for the donation of the painting, it still hangs in my study with its enduring images.

I had an enormous affection and admiration for Irv and Bea. He was an extraordinary human being who, without doubt, achieved extraordinary accomplishments. And, our profession and generations of optometrists are in his debt as well. But the welfare of humanity ultimately benefited. One of my heroes, the great Oliver Wendell Holmes, in 1885, prophetically said, “As life is action and passion, it is required of a man that he share the passion and action of his times, lest he be judged not to have lived.” To the members of the Borish family, I ask what more can be said of any human being!

Alden N. Haffner is President Emeritus, State University of New York State College of Optometry. This eulogy was reprinted with permission from Optometry, Journal of the American Optometric Association.

A Personal Reflection of Dr. Irvin M. Borish
Edwin C. Marshall, O.D., M.S., M.P.H.

Dr. Irvin Borish – not just the name, but the person – is synonymous with optometry, and the myriad contributions to his legacy helped mold the foundation upon which the profession stands today. Starting with my student-day introduction to the green-covered edition of Clinical Refraction and his classroom lectures at the Indiana University School of Optometry to his presence and welcoming support at my National Optometry Hall of Fame induction ceremony, Irv was a visible and integral part of my professional career.

During the formative years of my professional development, I would selfishly take delight in witnessing the apparent jealousy on the face of some of my non-IU colleagues upon their discovery that I had benefitted directly from the didactic and clinical teachings of the master clinician, educator, researcher, and inventor, Dr. Irvin Borish. What I gained from our sessions in the classroom and clinic, however, was only a small part of the influence he had upon my life. Probably what I cherish the most was the personal guidance and support that he provided during my early efforts to navigate the professional journey of academic and clinical optometry and the close friendship that evolved over the subsequent years. After becoming a professor, I had the opportunity and pleasure to invite Dr. Borish to do for my students what he had done for me – to share insights and pearls of wisdom from his vast repertoire of knowledge and experience. I fondly recall the frequent sidebar musings that we would have – or more appropriately that he would convey and I would listen – about the future direction of our profession and what we could or should do to help direct its path toward continued greatness.

An icon in the minds of most of those he encountered, Irv embraced and fostered fellowship, commitment, and service as uncompromising principles in his personal and professional citizenship. He was a repository of innovative ideas and an exemplar of the ideal, but yet the practical, and never too busy or otherwise too occupied to offer an instructive thought, a warm smile, or an inquisitive “do ya?” He was a man whose heart was his compass. I imagine that his strong devotion to his wife, Bea, his beloved profession of optometry, the IU School of Optometry that he helped found, and decades of mentees will be long recorded in the memories of those he touched and those who fell under the penumbra of his influence.

Edwin Marshall was a member of the Indiana University School of Optometry Class of 1971 and is currently Professor of Optometry and Vice President for Diversity, Equity, and Multicultural Affairs at Indiana University.

A Former Student Remembers
Neil Pence, O.D.

In trying to recall my first interactions with Dr. Irv Borish, the first word that comes to mind is “headache”. Before jumping to any conclusions, let me explain.

Our first exposure to Dr. Borish in the classroom was in
second year. In addition to teaching classes, he also directed the contact lens research clinic, and several of us had volunteered in that clinic, so I think he knew a few of our faces. Anyone who ever heard Dr. Borish lecture know that after he made a point, he would say “Do you see?”, or often seemed to get stuck on the “Do, Do, …”. I was never in the front few rows, but was maybe in the front third of the lecture hall in room 105, and maybe because he recognized me or maybe because he thought I was paying attention, but it felt like he was looking right at me when he would say “Do, Do, Do you see”. As a seemingly uncontrollable reflex, I would start nodding my head yes, to help get him unstuck and moving on. By the end of an hour, I would literally have a headache from so much nodding. I attempted to not nod, tried keeping my head down to avoid eye contact, etc. but invariably I would fall back into nodding yes every time he said “Do, Do, Do you see?”.

It was my great honor to have had the opportunity to work under Dr. Borish. I also had the pleasure on several occasions of examining Dr. Borish as a patient. That capacity led to several memorable moments, of which I will relate one. Dr. Borish nearly always had a package of contact lenses in his pocket containing four or five bifocal rigid lenses. I think manufacturers would send him pairs of any new designs for him to try. If a lens would bother him or need to be replaced for some reason, he would pull out the package and say “find me a good left lens”. I would verify them all, and on one occasion after selecting what seemed like the best alternative we found that he was over-minused by over one diopter. Since he was in his 70’s at the time, I offered to attempt to power some plus on the lens, to which he replied “Neil, I know you don’t think so, but I can still accommodate for that diopter just fine”. While I think it is much more likely explained by his very small pupils, I have never fully ruled out that this remarkable gentleman may have indeed had remarkable accommodative abilities as well.

Thank you Dr. Borish for all you did for the profession of optometry. Thanks also for the encouragement and kindness shown first to a student, and then to a young faculty member hoping to someday start to figure it all out.

Neil Pence was a member of the Indiana University School of Optometry Class of 1979 and is currently the school’s Associate Dean for Clinical and Patient Care Services.

Tribute to Dr. Irv Borish
Alfred A. Rosenbloom, Jr., O.D., M.A.

My friendship with Dr. Irv Borish goes back many years. I will always remember and greatly value the opportunity to lecture with him at several American Academy of Optometry continuing education courses. In our course, “Understanding, Evaluation, and Management of the Aging Patient,” we explored the significance of tinted lenses, contact lenses, special absorbing lenses, and other devices in inhibiting the vision deterioration of elderly patients. Environmental concerns and future professional services as needed were fully discussed.

During the mid-1940s, Dr. Borish along with a small group of colleagues began a campaign which successfully achieved the establishment of an optometry school at Indiana University. He became a part-time faculty member commuting from his office in Kokomo, Indiana to teach.

Acknowledged as a pioneer architect and authority, his textbook Clinical Refraction, published in 1949, later updated, continues to serve as one of the standard reference texts for optometric students. His textbook has been described as a universal text that has brought “philosophical-scientific unity to optometry.” Along with a few colleagues, he was influential in establishing states to allow optometrists to use diagnostic drugs followed later by the use of therapeutic drugs.

Irv was a multi-talented individual – he was also an accomplished artist and poet. An eight page section in his biography includes color reproductions of his paintings. Clearly, his most significant role was positioning optometry as a key provider in the overall health care system!

Alfred A. Rosenbloom is former President of Illinois College of Optometry and Director of Low Vision Services at the Chicago Lighthouse for the Blind.

Lessons Learned: A Genius with a Sense of Humor
Jack Runninger, O.D.

The better I got to know Irv Borish, via spending a great deal of time with him and his wife on various trips, the more I discovered him to be the most brilliant and amazing person I’ve ever known. His genius was in many fields, not just optometry.
I shuddered when I discovered how close we came to him not pursuing an optometric career. When he graduated from high school he decided to pursue a literary career, and enrolled at Temple University in Philadelphia. A year and a half later, fortunately(!) his uncle talked him into instead going to optometric school at Northern Illinois College of Optometry.

I once described him: “To be a genius is rare. To be a genius with common sense is even more rare. And to be a genius with common sense who is a really nice guy, is even more rare. That describes my friend Irv Borish, the rarest of the rare!”

Now as I contemplate his demise, I realize that there was another trait that set him apart. We usually picture a scientist of Borish’s brilliance as always being frowning and very serious. But he had a marvelous sense of humor despite a disadvantaged childhood. His parents were poor immigrants from Lithuania. His father had tuberculosis, which necessitated staying in a sanitarium in the Catskills, and the family had very little income.

The Catskills region was the spawning ground of the marvelous Jewish comedians who later became so famous. I always wondered if being raised in the Catskills wasn’t one source of Borish’s great sense of humor:

“The daughter of a Jewish merchant became engaged to a jobless Talmudic scholar,” began perhaps his favorite story. “‘How do you expect to support my daughter without a job?’ the merchant asked the suitor-scholar. ‘God will provide,’ he said.”

“Later someone asked the merchant how he got along with his up-coming son-in-law. ‘Fine,’ he replied. ‘He thinks I’m God.’”

Borish’s fascinating life is described in the wonderful biography written by his close friend, Dr. Bill Baldwin. My favorite story in his repertoire was about the little old man dining in a restaurant. He hailed his waiter and said, “Taste the soup.”


“Okay, okay,” said the waiter. “Where’s the spoon?” “Ah HAH!” said the diner triumphantly.

Jack Runninger practiced in Georgia. He is a consulting editor and columnist for Optometric Management magazine. Dr. Runninger’s tribute to Borish was excerpted with permission from Optometric Management.

Irvin M. Borish: A Short Biographical Sketch
David A. Goss, O.D., Ph.D.

Irvin Max Borish was born January 21, 1913 in Philadelphia. His father, Max Borish, immigrated to the United States from what was then eastern Poland. His mother, Rose Gimson Borish, came to the United States from Lithuania.1

Following graduation from high school in Liberty, New York, in 1929, Borish enrolled in Temple University with the goal of becoming a writer. Although he excelled in his classes at Temple, the onset of the Great Depression led him to consider whether another future profession might offer better economic prospects. He was convinced by an uncle to study optometry at the Northern Illinois College of Optometry (NICO) in Chicago. While in Chicago, Borish met Bea Silver, whom he would marry in 1936 and who would be his life mate until her death in 2001.

Borish graduated from NICO in 1934. He then practiced optometry in Chicago, until he accepted a faculty position at NICO in 1936. During his years at NICO, Borish served the school in many roles, including professor, director of clinics, assistant dean, and registrar. In those years, he also co-authored a manual for accreditation of schools and colleges of optometry and played an important role in the formation of the Association of Schools and Colleges of Optometry. In 1938, he published a textbook entitled Outline of Optometry.

In 1944, Borish left Chicago to establish an optometry practice in Kokomo, Indiana. Soon after his arrival in Indiana, he joined John Davey, Noah Bixler, and other Indiana optometrists in their efforts to establish an optometry school at Indiana University. As leaders of the Indiana Optometric Association School Committee, Borish and John Davey met regularly with IU President Herman Wells and Vice-President Herman Briscoe.2 After years of work and preparation, the pre-professional optometry courses were begun in 1951,
with professional classes beginning in 1953. Borish became a part-time optometry faculty member at IU, commuting weekly from his home in Kokomo.

After World War II, enrollments in optometry schools increased and copies of his textbook Outline of Optometry soon sold out. Borish went to work on an updated and expanded textbook. In 1949, the first edition of Clinical Refraction was published, followed by a second edition in 1954. For the third edition, Borish recruited an expert group of 19 collaborators and the book expanded to 1,381 pages. Clinical Refraction became optometry’s most famous book. An American Optometric Association publication called it “optometry’s bible,” and in a survey in which respondents listed what they thought were the most important 20th century optometry books, it received the most nominations. Twenty-eight years later marked the publication of a new book, Borish’s Clinical Refraction, composed with the same level of comprehensiveness and authority of Borish’s 1970 book, and with Borish serving as a consultant and one of the authors. The second edition of Borish’s Clinical Refraction appeared in 2006, with Borish co-authoring chapters on refraction and bifocal contact lenses at more than 90 years of age.5

Among Borish’s areas of particular expertise were contact lenses, optometric testing procedures, and binocular refraction. He held several patents in the United States and Canada for methods for the modification of contact lens refractive power and for bifocal contact lenses. In 1978, he introduced the Borish nearpoint chart, a polarized chart for testing binocular function at near.6

In 1973, Borish left private practice to become a full-time faculty member in the IU School of Optometry. He taught courses in refractive analysis, was clinic director from 1978 to 1982, and established a strong contact lens research program. In 1979, Clifford Brooks and Borish published System for Ophthalmic Dispensing, a textbook on the selection, measurement, ordering, verification, dispensing, optics, and adjustment of spectacles. A second edition appeared in 1996 and a third in 2007. In the early 1980s, Borish published some of the first studies on the effectiveness of progressive addition spectacle lenses, leading to their wide acceptance among practitioners.7,8 Borish retired from the IU faculty in 1983. He then held a position as the first Benedict Professor of Optometric Practice at the University of Houston College of Optometry from 1983 to 1989.

Throughout his career Borish was in great demand as a continuing education lecturer. He presented at national, regional, and state conferences all over the United States and in more than 45 other countries. He also spoke frequently at optometry schools across the country, and continued to do so until well into his 90s.

He served on a number of committees of the American Optometric Association and the American Academy of Optometry. His expansive knowledge of optometry, his many service activities in optometry, and the fact that he was a student of optometry history made him valuable as an advisor to optometry leaders and optometry school administrators. He was one of the leaders of the movement to expand the scope of optometry practice into areas previously exclusively the province of medicine, but he was quick to point out that it was essential that the optometric profession maintain its expertise in refraction and binocular vision.9-11

Borish always championed the importance of research in optometry. One of his legacies is the Borish Center for Ophthalmic Research established at IU in 1995, as a center for patient-based research in optometry.

Among Borish’s interests outside of optometry were rose gardening and painting. Some of his paintings have been sold at auctions to benefit the American Optometric Foundation. Many of his paintings are displayed in a book produced by the spectacle lens company Essilor commemorating his 90th birthday. On a personal note, I can recall Borish lecturing to my class when I was an optometry student at Pacific University in the early 1970s. I still have my third edition of Clinical Refraction which I had him sign at that time. In the late 1970s, when I was a graduate student at IU, he was a member of my thesis committee. More recently, I enjoyed some in-depth conversations with him when I was preparing a history of the founding and early years of the optometry school at IU.

Borish received many awards from various organizations and institutions, including eleven honorary degrees from optometry schools.1 Among the most significant of his awards were the American Optometric Association Apollo Award (1968), American Optometric Association Honorary Life Fellowship (1980), National Academy of Practice
Distinguished Practitioner (1982), American Academy of Optometry William Feinbloom Award (1985), American Academy of Optometry Max Schapero Memorial Award (1987), American Optometric Association Contact Lens Person of the Year (1988), American Optometric Association Distinguished Service Award (1989), Prentice Society Award for Excellence in Clinical Education (1992), World Council of Optometry Optometrist of the Year (1996), and one of the first two inductees into the Optometry Hall of Fame (1998). In 1999, he was voted “the most influential optometrist of our time” by readers of Review of Optometry. He received an honorary LLD degree from IU in 1968, and the Herman B Wells Visionary Award in 2002. Irvin M. Borish died on March 3, 2012, in Boca Raton, Florida.

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A Survey on Parental Knowledge of Pediatric Vision Care

SCOTT CAUGHELL, O.D., DAVID A. G OSS, O.D., PH.D., AND CARL HARDER, O.D.

Despite the fact that vision disorders are very common in children, many children do not have the benefit of comprehensive eye and vision examinations. The American Optometric Association recommends that asymptomatic risk-free children have eye and vision examinations at six months of age and three years of age, and then before first grade and every two years thereafter. A 2008 American Optometric Association survey estimated that only about 44% of American children have a comprehensive eye exam before the age of five. One possible explanation is a lack of knowledge on the part of parents. This paper reports the results of a survey of parental knowledge of pediatric vision care.

Methods
A series of questions were written to examine the knowledge of parents about pediatric vision care. The survey questions and procedures used in this study were approved by the Indiana University Human Subjects Committee. Parents of children being examined in three Indiana University Optometry Clinics (Atwater Eye Care Center and Community Eye Care Center in Bloomington and Indianapolis Eye Care Center) were given a survey to evaluate their knowledge on pediatric eye and vision care. There were 134 participants from the Atwater Eye Care Center, 55 from the Community Eye Care Center, and 37 from the Indianapolis Eye Care Center, making a total of 226 participants overall. This survey was conducted in 2007. For the yes/no questions, percentages were used to show the results. For questions with numerical answers, means and standard deviations were used to show the results.

Results
The questions asked and the results of the survey were as follows:

Question 1: Please write in the age of your child being examined today. The average age was 7.6 years with a standard deviation of 3.3.

Question 2: Is this the first full eye exam that your child has had with an Eye Doctor (Optometrist or Ophthalmologist)? (Please answer “yes” if your child has only had a vision screening done by a school, nurse, or pediatrician’s office) The percentage of parents responding “yes” was 38.1%. Of these children who were having their first eye and vision examination, the mean age as answered in question 1 was 6.3 years, with a standard deviation of 3.1. When a breakdown by clinic was done, the average ages were: Atwater Eye Care Center, 6.0 years (SD=3.1); Community Eye Care Center, 7.5 years (SD=2.9); Indianapolis Eye Care Center, 5.6 years (SD=3.4).

Question 2A: If this is not your child’s first eye exam by an eye doctor, how old was your child at his/her first eye exam? The average age was 4.9 years with a standard deviation of 2.6.

Question 2B: If this is not your oldest child, how old was your oldest child at his/her first eye exam? The average age was 5.9 years with a standard deviation of 3.2.

Question 3: How old was your child the first time he/she saw the Dentist? The average age was 3.1 years with a standard deviation of 1.9.

Question 4: Why did you have your child’s first eye exam at this age? (choose all that apply) There were 13 possible reasons listed labeled A through M. Those reasons and the percentages of parents marking them were:

A. Just want to make sure his/her eyes are healthy and working properly (Child has no signs of problems): 40.2%.
B. Child sits close to TV or holds books close: 15%.
C. Child is starting school: 10.6%.
D. Family eye problems/diseases: 23.9%.
E. Think child may have an eye turn or “lazy eye”: 16.4%.
F. Child has a red/watery eye or other injury: 1.8%.
G. Child told you he couldn’t see chalkboard or other objects: 14.2%.
H. Child is having trouble at school: 12.4%.
I. Family or friends recommended an eye exam for the child: 4.4%.
J. Other professional (pediatrician/nurse/other)
recommended it: 23.9%.
K. Saw a TV ad or pamphlet about importance of
children’s eye exam: 2.2%.
L. Friend or related child had an eye problem: 6.2%.
M. Other: 22.6%.

Question 5: If your child is/was older than 1 year old at
his/her first eye exam, what may have caused you to not
bring him/her in sooner? Please rank up to your first 2
choices by putting a number 1 next to the main reason
and a number 2 on the second reason.
A. My child was seen before 1 year old by an
Optometrist/Ophthalmologist: 6.2% of parents said this
was their main reason and 1.3% of them said this was
their second reason.
B. Did not think an eye exam could be done on young
children and infants: 21.2% said this was their main
reason and 9.7% said this was their second reason.
C. Child did not appear to have any problems thus
thought didn’t need an exam: 42.5% main reason and
17.7% second reason.
D. Cost: 3.1% main reason and 4% second reason.
E. Thought a pediatrician/ nurse/ school screening would
find any problems: 9.7% main reason and 23% second
reason.
F. Did not know babies and infants can have vision
problems: 1.3% main reason and 3.1% second reason.
G. Don’t think untreated vision/eye problems in children
will cause any long term effects: 0% main reason and
1.3% second reason.
H. Other: 8%.

Question 6: If you think a child can see well and doesn’t
appear to have any problems, when do you think their
first eye exam should be?
A. Within the first year of age: 8%.
B. 1 to 2 years old: 18.1%.
C. 3 to 4 years old: 34.6%.
D. 5+ years old: 33.7%.
E. Never if no problems are noticed: 2.2%.

Question 7: Do you think that a meaningful eye exam
can be performed at: (Circle Yes or No on All)
A. 6 to 12 months? 37.2% of parents said yes and 60.2%
said no.
B. 1 to 3 years? 67.3% said yes and 28.3% said no.
C. 4 to 6 years? 93% said yes and 2.2% said no.
D. 7 and older? 95.1% said yes and 0% said no.

Question 8: Behavioral problems are a sign that your
child’s vision may be impaired: (Circle Agree or
Disagree)
68.1% of parents agreed and 26.1% disagreed.

Question 9: Have you ever heard of the InfantSEE
program where participating optometrists provide free
eye exams for children under 1 year old?
7.1% of parents said yes and 90.3% said no.

Question 10: The American Optometric Association
recommends an eye exam by an Eye Doctor at 6 months,
3 years, 5 years and throughout school. Have you ever
heard or seen these recommendations?
13.7% of parents said yes and 84.6% said no.

Question 11: The state of Kentucky requires a
mandatory full eye exam by an optometrist or
ophthalmologist before the child enters school. Do you
believe that this is a good requirement?
93% of parents said yes and 4.9% said no.

Question 12: Did you know that eye screenings with an
eye chart miss up to 1 out of 3 eye problems, and that
these problems can greatly affect a child’s ability to learn
and do well in school?
25.7% of parents said yes and 71.2% said no.

Discussion
Over two-thirds of the parents did not know that visual
acuity screening could miss significant numbers of vision
problems (Question 12). Over a third of the parents
thought that it would be appropriate to wait until five
years of age or later for their children’s first vision exams
if there didn’t appear to be any problems (Question 6).
This could result in some apparently asymptomatic
conditions such as amblyopia being missed. However, it
is interesting to note that over 90% felt that it would be
good to require children to have a full eye exam before
they enter school.

The results of this study suggest that parental knowledge
of pediatric vision care could be improved in several
areas. In addition to educating parents, optometrists
could perhaps also work more closely with primary care
physicians and pediatricians to encourage early eye and
vision examinations. Areas in which optometrists could
strive to educate parents are as follows:
● That an eye exam can be performed on children less
than one year of age.
● That early vision care is as important as early dental
care.
● Existence of the Infant SEE program
● That for asymptomatic, risk-free children, the
American Optometric Association recommends eye
exams at 6 months and at three years, and then before
first grade and every two years thereafter.
● That vision screenings do not substitute for a
comprehensive eye and vision examination.
References

Scott Caughell is a graduate of the Indiana University School of Optometry. He completed a residency in Pediatrics and Binocular Vision at IU. He is a Fellow of the American Academy of Optometry and practices in Warsaw, Indiana. Carl Harder is a 2011 graduate of the IU School of Optometry.
A Report on Visual Discomfort Associated with Viewing 3D Media

DAVID A. GOSS, O.D., PH.D.

Recent years have seen an expansion in the use of three dimensional displays in movies, television, computer games, education, and other applications. It has been estimated that 80% of individuals can see 3D media comfortably.\(^1\) About 2 to 5% can’t see 3D, and the remaining 15 to 18% have visual discomfort associated with viewing 3D media. One survey found the most common symptom to be tired eyes, followed in frequency by headache, dizziness, and nausea.\(^2\)

Review papers have identified two potential sources of discomfort associated with 3D media.\(^3,4\) The first is a mismatch of accommodation and convergence stimuli. In everyday viewing, accommodation and convergence stimuli are in the same plane. With 3D media, the convergence stimulus plane is shifted toward or farther from the viewer than the plane of the accommodative stimulus. This type of mismatch of accommodation and convergence stimuli is of course routinely used clinically when testing fusional vergence ranges or when doing vision therapy with procedures such as Tranaglyphs, Vectograms, or aperture rules. The second potential source of discomfort is visually induced motion sickness in which visual input suggests that the viewer is in motion while vestibular input suggests that the viewer is not in motion.

The remainder of this article (1) provides a brief summary of a paper by Shibata et al.\(^5\) in which experiments explored the relation of the 3D viewing discomfort to the accommodation and convergence stimulus mismatch and (2) reports on a three-hour continuing education course on 3D viewing at the 2012 American Optometric Association meeting.

**Experiments by Shibata et al.**

Shibata et al.\(^5\) conducted a series of three experiments in which they related levels of eye tiredness, blur, visual comfort, and headache symptoms to various viewing conditions and optometric test results. The first experiment was conducted in a haploscope and compared visual discomfort from accommodation and convergence stimulus mismatches for accommodative stimulus levels of 0.1, 1.3, and 2.5 D. There was more discomfort experienced when the convergence stimulus differed from the 0.1 D accommodative stimulus than when it differed from the 1.3 or 2.5 D accommodative stimuli. The authors suggested that there may be more discomfort associated with accommodation and convergence stimulus mismatches at far than at near. Of course, there may be some question as to whether the results in a haploscope apply to viewing in real space.

The second experiment looked at the effect of the direction of the change in convergence stimulus away from the accommodative stimulus on discomfort. This experiment was also conducted in a haploscope. Accommodative stimuli were again 0.1, 1.3, and 2.5 D. Convergence stimuli were changed to planes behind the plane of the accommodative stimulus and in front of the accommodative stimulus. For the 0.1 D accommodative stimulus, simulating far viewing, discomfort was greater when the convergence plane was shifted behind the accommodative plane than when it was in front of the plane of accommodation. For the 2.5 D accommodative stimulus, simulating near viewing, there was more discomfort when the convergence plane was closer to the subject than the accommodative plane than it was when the convergence plane was farther from the subject than the accommodative plane. There was no overall trend for the 1.3 D accommodative stimulus.

In the third experiment, the investigators looked at the relation of von Graefe dissociated phorias and variables based on phoropter fusional vergence ranges to the symptoms levels from the first two experiments. They determined correlation coefficients for the relation of symptom questionnaire results to the amount of the phoria and to the values derived from Sheard’s criterion and Percival’s criterion calculations. A total of 120 correlation coefficients were calculated using the various survey question, distance, and experiment conditions. They found that many more correlations were significant than would have been expected by chance. They concluded that dissociated phoria and the zone of clear single binocular vision are related to the likelihood of visual discomfort from viewing 3D displays.

In the Discussion section of the paper, the authors expounded not only on their own results, but also on various observations and findings from other studies. It was noted that visual discomfort at 3D movies is greatest when sitting closer to the screen and least when sitting farther from the screen. Another discussion point was the fact that television manufacturers recommend a viewing distance of three times the screen height. However, studies of preferred viewing distance have
James Sheedy, O.D., Ph.D., discussed his research on vision and 3D media. He noted that the 3Ds of 3D can be discomfort, dizziness, and no depth. He discussed the zone of comfort for 3D television and movies within the zone of clear single binocular vision. He observed that it is much narrower than Percival’s zone of comfort which is the middle third of the lateral width of the zone of clear single binocular vision. He thinks that it may be narrower in part because the convergence stimulus is often changing rapidly in 3D movies and television, making the viewer reacquire stereopsis quickly with each change in convergence stimulus.

Sheedy also mentioned methods of displaying 3D. The two primary methods are active systems with shutter glasses and passive systems with polarized glasses. He noted that passive systems tend to yield brighter images than active systems, thus leading to greater subjective immersion in the material being viewed. Also there is less cross-talk with passive systems which may explain why some people have less discomfort with passive systems than with active.

Philip Corriveau, Principal Engineer with Intel Corporation and member of the Human Factors Steering Team of the 3D@Home Consortium (www.3dathome.org), said that efforts were being made to translate subjective aspects of viewer experience to objective metrics to attempt to define technology variables that impact user experience. He noted that the quantity and quality of 3D television content is limited at present, but will be increasing.

Michael Duenas, O.D., Chief Public Health Officer with the American Optometric Association talked about 3D as a public health matter. He observed that 3D might be used as a way to encourage people to get an optometric vision examination. It might also be possible to use 3D in vision screening programs to improve sensitivity of vision screening for various problems. Further information is available at: www.3deyehealth.org.

Dominick Maino, O.D., M.Ed., noted that visual discomfort with 3D viewing could perhaps be called 3D Vision Syndrome and that most persons with self-reported difficulty with 3D media have diagnosable binocular vision problems. Clinical testing should include binocular vision, accommodation, stereopsis, and vertical alignment. Vision therapy can be used for the alleviation of 3D Vision Syndrome.

Len Scrogan, M.Ed., an educator with expertise in instructional technology, reported that there are over a million 3D projectors installed in classrooms in the United States, although they haven’t been fully implemented. There appear to be positive educational benefits in better conceptualization and model building with 3D instructional materials. Implementation may be limited when educators have vision problems and therefore do not recognize its value. This is an opportunity for collaborations of optometry and education.

Private practitioner Donna Matthews, O.D., was inspired by the book Fixing My Gaze by Susan Barry to incorporate 3D media into her practice. She uses 3D to screen patients in her office.

Slit lamp biomicroscopes are now being produced for heads-up viewing, with depth achieved by polarization rather than looking through slit lamp oculars. More information about this continuing education program can be found on the Vision Help blog.

References
Convergence Accommodation to Convergence (CA/C) Ratios: A Potential Clinical Diagnostic Tool
DAVID A. GOSS, O.D., PH.D.

Accommodative convergence to accommodation (AC/A) ratios are a routine part of an eye and vision examination. In contrast, the clinical determination of convergence accommodation to convergence (CA/C) ratios is uncommon. Measurement of AC/A ratios requires the elimination of the stimulus to fusional vergence in order to reveal the effect of accommodation on vergence. This is easily done with dissociated phoria tests. Measurement of CA/C ratios requires the elimination of blur cues to accommodation to reveal the effect of vergence activity on accommodation. CA/C ratios have not been included in a standard eye and vision examination, in part because there are no routine clinical procedures for eliminating blur cues to accommodation.¹

Even though CA/C ratios are not routinely determined, they could help to understand the visual function of patients. Consider, for example, the following case. A patient with a dissociated phoria of ortho at distance and a high AC/A ratio would show esophoria at near. Negative fusional vergence would be used to achieve fusion. If the patient had a high CA/C ratio, that negative fusional vergence would result in a significant decrease in accommodation. There then could be a compensatory increase in accommodation to reduce blur, with associated accommodative convergence. Theoretically these adjustments back and forth could result in unstable vision or reach an equilibrium with some amount of eso fixation disparity and/or a high lag of accommodation.²,³

If a high AC/A ratio is accompanied by a CA/C ratio which is moderate or high, there is greater likelihood that there will be a fixation disparity or a high accommodative error.²,³ CA/C ratios may thus help to explain different symptom levels in patients with the same dissociated phorias.

Measurement of CA/C Ratios
One type of target that provides minimal indication of change in blur is a difference of Gaussian pattern.⁴ This type of target is found on the back of later versions of the Wesson Fixation Disparity Card. A difference of Gaussian pattern has a blurred light bar with blurred dark bars on either side of it (see Figure 1). A CA/C ratio could be determined by comparing dynamic retinoscopy findings with and without prism while the patient viewed such a target. The numerator in the CA/C ratio would be the difference in dynamic retinoscopy findings and the denominator would be the power of the prism. Base-in prism has been recommended because there is usually less vergence adaptation with base-in than with base-out.¹,⁴

It has also been suggested that CA/C ratios could be calculated by performing the binocular cross cylinder (BCC) test with different amounts of prism. However, it has been reported that accommodative response changes as lenses are varied on the binocular cross cylinder test,⁵,⁶ suggesting that cues to accommodation are not eliminated. Despite that fact, one study found similar CA/C ratios with binocular cross cylinder, dynamic retinoscopy, and haploscopic testing.¹

CA/C ratios can be calculated by dividing the difference in accommodative response with two different prism stimuli by the difference in the two prism powers. Alternatively, if several prism powers are used, the slope of a regression equation looking at accommodative response as a function of prism power could be used to determine CA/C. Units for CA/C ratios can be either dioptries per prism diopter (D/Δ) or dioptries per meter angle (D/MA). Meter angles are equal to prism dioptries divided by interpupillary distance in centimeters. In the discussion below of papers from the literature on CA/C ratio, CA/C ratios will be
presented in D/Δ obtained by dividing those reported in D/MA by an arbitrary value of 6.

Studies Measuring CA/C Ratios Using Optometers or Autorefractors
Most studies in the literature reporting CA/C ratios have used an optometer or open-field autorefractor to measure accommodation. Published values have shown some variation. Examples of the mean CA/C ratios from studies that used an optometer or refractometer to measure accommodation are:

(a) Kent,7 0.13 D/Δ (17 subjects, 9.5 to 48 years of age, SD of CA/C = 0.06);
(b) Hung et al.,8 0.12 D/Δ (22 asymptomatic subjects, 18 to 24 years old, SD = 0.05);
(c) Hung et al.,8 0.11 D/Δ (21 symptomatic subjects, 19 to 30 years old, SD = 0.05);
(d) Rosenfield and Gilmartin,9 0.06 D/Δ (30 young adult subjects);
(e) Kotulak et al.,10 0.10 D/Δ (16 subjects, mean age = 25.4 years; SD of CA/C = 0.08);
(f) Nonaka et al.,11 0.08 D/Δ (78 patients with exophoria or intermittent exotropia, mean age = 12.9 years, SD of CA/C = 0.04);
(g) Brautaset and Jennings,12 0.14 D/Δ (10 subjects with convergence insufficiency, mean age = 25 years, SD of CA/C = 0.02); and
(h) Fukushima et al.,13 0.09 D/Δ (16 subjects, ages 22 to 25 years, SD = 0.04).

The variability in results from different studies could be explained by differences in methods of measuring accommodation, in ages of subjects, in amounts of convergence or divergence stimulated, in time over which vergence adaptation may have occurred, and in visual characteristics of the subjects. Some of those studies reported stimulus CA/C ratios (change in convergence stimulus in the denominator) and some reported response CA/C ratios (change in convergence response in the denominator). However, because there is typically little difference between vergence stimulus and vergence response, it is expected that there will be little difference between stimulus CA/C ratios and response CA/C ratios. CA/C ratio appears to decrease with decreases in amplitude of accommodation, when the amplitude is less than about 10 D. Thus in adults, CA/C ratio shows a negative correlation with age.14

Studies Measuring CA/C Ratios Using the BCC Test or Dynamic Retinoscopy
Schor and Narayan1 reported CA/C ratios with three different methods of measuring accommodation on five subjects. Accommodation measurements were taken with the BCC test, Nott dynamic retinoscopy, and a coincidence optometer in a haploscope. Accommodation was measured with no prism and with 6Δ base-in. The change in accommodation was divided by the change in the dissociated phoria going from no prism to the 6Δ base-in prism. Test distances for the BCC test and for Nott retinoscopy were 40 cm. The CA/C ratios presented in the paper were averages of five such determinations for each test method for each subject. Mean CA/C ratios were 0.087 D/Δ (SD=0.032) with the BCC test, 0.08 D/Δ (SD=0.025) for Nott retinoscopy, and 0.075 D/Δ(SD=0.025) for the coincidence optometer. The coefficients of correlation relating the CA/C ratios with clinical accommodation measures to those with optometer measurements of accommodation were high (r=0.9).

Tsuetaki and Schor15 used Nott dynamic retinoscopy to measure accommodation and compute CA/C ratios. Testing was done in a phoropter with subjects viewing through no prism and twelve different prism settings. Subjects viewed a difference of Gaussian target. CA/C ratios were calculated by linear regression of accommodative response as a function of vergence stimulus. Six subjects who ranged in age from 20 to 38 years had a mean CA/C ratio of 0.045 D/Δ (SD = 0.022). When they tested the same subjects using an optometer to measure accommodation and an infrared eye movement monitor to measure vergence, they obtained a mean CA/C ratio of 0.055 D/Δ (SD = 0.021).

Daum et al.4 measured CA/C ratios by performing MEM dynamic retinoscopy through no prism and through 6Δ base-in while subjects viewed a difference of Gaussian target. Subjects were 18 to 35 years of age and were divided into asymptomatic and symptomatic groups based on a survey of headache, eyestrain, blur, slow focusing, and diplopia symptoms. The mean CA/C ratio for the 78 subjects in the asymptomatic group was 0.06 D/Δ (SD = 0.05). For the 22 subjects in the symptomatic group, the mean CA/C ratio was 0.07 D/Δ (SD = 0.06). The difference in CA/C ratios between the two groups was not statistically significant (p>0.05). The range of CA/C ratios extended from three with negative ratios (increase in accommodative response with base-in prism rather than a decrease) to a high of 0.25 D/Δ. They concluded that the negative CA/C ratios were due to measurement errors.

Wick and Currie16 determined CA/C ratios using Nott dynamic retinoscopy while subjects viewed a difference of Gaussian target at 40 cm. Accommodative response was determined for prism powers of 3, 6, 9, and 12 Δ, both base-in and base-out, for as many of the prism powers that could be fused. The CA/C ratio was calculated by a regression equation of accommodative response as a function of vergence stimulus. They...
tested 40 subjects who ranged in age from 9 to 38 years. A mean CA/C ratio was not reported, but based on a figure in the paper, CA/C ratios with Nott retinoscopy ranged from close to 0 to about 0.06 D/Δ, with a median of about 0.035 D/Δ. Eleven of their subjects had CA/C ratios determined by both dynamic retinoscopy and an optometer in a haploscopic arrangement. The coefficient of correlation of Nott retinoscopy CA/C with optometer CA/C was 0.79.

Comments
Mean CA/C ratios from different studies are summarized in Table 1. All of the studies in which accommodation was measured with the BCC or with dynamic retinoscopy found mean (or median) CA/C ratios to be less than 0.1 D/Δ and sometimes much less than that. Many of the studies in which accommodation was measured with an optometer found mean CA/C ratios to be more than 0.1 D/Δ.

Clinical procedures that would allow the determination of CA/C ratios exist today. CA/C ratios may have some promise for analysis of binocular vision problems with further research and development. Some optometrists have suggested graphical procedures for analysis of AC/A and CA/C ratios. The application of CA/C ratios as a useful clinical analytical tool would require standardization of measurement methods, establishment of norms, and development of analysis procedures in concert with AC/A ratios and other clinical findings.

References
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Table 1. Mean CA/C ratios in diopters per prism diopter. Standard deviations are in parentheses. Separate columns indicate the method by which accommodation was measured.

<table>
<thead>
<tr>
<th>Study</th>
<th>BCC</th>
<th>Dynamic Retinoscopy</th>
<th>Optometer</th>
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<tr>
<td>Kent (n=17)</td>
<td>0.13 (0.06)</td>
<td>0.12 (0.05)</td>
<td>0.10 (0.08)</td>
</tr>
<tr>
<td>Hung et al. (22 asymp.)</td>
<td>0.12 (0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hung et al. (21 symp.)</td>
<td>0.11 (0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosenfield &amp; Gilmartin (n=30)</td>
<td>0.06 (SD not given)</td>
<td>0.06 (0.05) (Nott)</td>
<td>0.075 (0.025)</td>
</tr>
<tr>
<td>Kotulak et al. (n=16)</td>
<td>0.09 (0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonaka et al. (78 with exo)</td>
<td>0.08 (0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brautaset &amp; Jennings (10 with CI)</td>
<td>0.14 (0.02)</td>
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<tr>
<td>Fukushima et al. (n=16)</td>
<td>0.09 (0.04)</td>
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</tr>
<tr>
<td>Schor &amp; Narayan (n=5)</td>
<td>0.087 (0.032)</td>
<td>0.08 (0.025) (Nott)</td>
<td>0.075 (0.025)</td>
</tr>
<tr>
<td>Tsuetaki &amp; Schor (n=6)</td>
<td>0.045 (0.022) (Nott)</td>
<td>0.055 (0.021)</td>
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<tr>
<td>Daum et al. (78 asymp.)</td>
<td>0.06 (0.05) (MEM)</td>
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<td></td>
</tr>
<tr>
<td>Daum et al. (22 symp.)</td>
<td>0.07 (0.06) (MEM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wick &amp; Currie</td>
<td>median about 0.035 (Nott)</td>
<td>median about 0.04</td>
<td></td>
</tr>
</tbody>
</table>


