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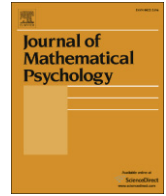
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In Memoriam

Tarow Indow (August 22, 1923 to September 22, 2007)

Tarow Indow, a member of the editorial board of this journal since 1974, died on September 22, 2007, at a hospital near his home in Irvine, California. His wife, Minako, and a brother and sister in Japan survive him. At the time of his death he was Professor Emeritus at Keio University in Tokyo and at the University of California, Irvine, where he was a member of the Department of Cognitive Sciences and the Institute for Mathematical Behavioral Sciences. He remained an active researcher until the final weeks of his life.

At a memorial service held at UCI on December 5, 2007, tributes and reminiscences focused on three themes. First, and foremost, was Tarow's extraordinary scholarship and technical mastery in experimental and mathematical psychology generally, but especially in visual perception. In particular, he was described as the leading authority of his time on geometrical representations of perceived color, as well as on the geometrical structure of visual space itself. A second theme was Tarow's personal embodiment of the ideals of academic professionalism and collegiality. Applied to him, the phrase "a gentleman and a scholar" was not a quaint cliché, but the simple truth. Finally, many affectionate messages testified to the warm friendships Tarow and Minako made around the world during his long international career.

Tarow Indow was born in Tokyo on August 22, 1923. Health problems kept him from military service during World War II, allowing him to pursue his university studies, although not without a stint of mandatory factory labor. In 1945, he received a B.A. from Keio University, and shortly afterward joined the faculty there as an instructor of psychology. He continued with graduate studies at Keio while rising through the academic ranks: assistant professor in 1953 (the year he and Minako were married) and, following a 1959 Ph.D., a full professorship in psychology in 1961. Like many leading Japanese psychologists of that era, Tarow's graduate advisor, Professor Matsusaburo Yokoyama, had received his own Ph.D. from G. Stanley Hall's department at Clark University, where his advisor was E.G. Boring (Nishikawa, 2005).

Tarow's interests were mathematical from the start. In an autobiographical account of this period Indow, 1995 he mentions the influence of articles by L.L. Thurstone and chapters by Selig Hecht and W.J. Crozier in Murchison's 1934 *Handbook of General Experimental Psychology* (Murchison, 1934). A seminal event was a prolonged visit to the Educational Testing Service in Princeton in 1951, where he read the dissertations of ETS Psychometric Fellows Warren Torgerson and Frederick Lord and Rudolph K. Luneberg's *Mathematical Analysis of Binocular Vision* (Luneberg, 1947), discovered by chance in the Princeton University bookstore. That discovery triggered 50 years of research on the geometrical properties of the visual world, summarized in his 2004 book *The Global Structure of Visual Space*. In these student years Tarow also began his study of the Munsell color system, motivated by an opportunity to apply the new tools of multidimensional scaling and by the fact that serious experiments required only inexpensive

colored chips. His final scientific publication (Indow & Romney, in press) deals with these same Munsell chips, continuing with electronic computers a research program begun a half-century earlier with a hand-powered mechanical calculator.

Tarow remained at Keio as a professor of psychology until 1979, when he retired to move to UCI. He also taught in Keio's School of Engineering and at other Japanese universities – Tokyo, Kyoto, Kanazawa – and in addition to doing basic research (on memory and concept formation as well as on perception) he was very active as an applied experimental psychologist and psychometrician, consulting for industry and government on problems such as scaling tastes and testing mental abilities. Between 1945 and 1977 he published more than 100 articles in Japanese and authored or edited six books in that language—one a statistics text, three on psychological measurement, and two, in 1969 and 1973, on the new field of "mathematical psychology". (These books are listed in Indow, 1995.) As the leading Japanese expert in many areas of psychology, he was increasingly called upon to participate in scientific meetings in Europe and the United States, and international travel came to play a major role in his and Minako's lives. These travels were greatly facilitated by Minako's fluency in several western languages, acquired as a child when her diplomat father was stationed abroad and sharpened by several years of teaching English in post-war Japan. Tarow became particularly involved with the Association Internationale de la Couleur, serving on its Executive Committee from 1969 to 1981 and as president from 1973 to 1979. In 1989 the AIC awarded him its highest honor, the Deane B. Judd Award. A picture of this gold medal hung above the desk in his otherwise totally austere office at UCI. Another honor coming in the 1980s that was especially meaningful to Tarow was his election (1986) as a Fellow of the Society of Experimental Psychologists, an organization that Professor Yokoyama had often spoken of with deep respect.

Tarow's career in the United States began with visiting appointments, starting with an invitation from S.S. Stevens to spend two years as a research fellow at Harvard's Laboratory of Psychophysics in 1963–1966. When that fellowship ended, he extended his stay for some months as a visiting scholar with Herbert Simon and Allen Newell at the (then) Carnegie Institute of Technology. During his Harvard years Tarow met Duncan Luce, who later invited him to spend 1971–1972 as a visiting member of the Institute for Advanced Study at Princeton. Subsequently Luce was instrumental in arranging a visiting professorship at UC Irvine in 1977–1979, to explore the possibility of filling a position that Luce himself had recently vacated to move to Harvard. At Irvine Bill Batchelder, Louis Narens, and Jack Yellott were working to create a new mathematically oriented department (eventually, UCI's Department of Cognitive Sciences) and made Tarow's recruitment a top priority. That effort succeeded, and in 1979 Tarow became Professor of Psychology at UCI. He retired from that position in 1993 to become Professor Emeritus. His retirement, coupled

with his 70th birthday, led to a week-long festschrift conference in July 1993. Papers from that meeting were published as the book *Geometrical Representations of Perceptual Phenomena* (Luce, D'Zmura, Hoffman, Iverson & Romney, 1995). Tarow's own chapter there includes the autobiographical piece cited earlier as well as a complete bibliography of his publications in English up to 1993. (His later publications are listed at the end of this article.)

To his colleagues at UCI, Tarow's retirement seemed only a formality; he continued to spend every day in the office, working as hard as ever, with time off only for meetings. But it did mark the end of his experiments on visual space perception. He dismantled his famous visual-alleys apparatus, a wonderful room-size contraption in which subjects maneuvered tiny light bulbs mounted on remote-controlled trolley cars (or sometimes, dangling on cables from the ceiling), trying to form perceptual point-arrays with prescribed geometrical properties such as apparent straightness and parallelism. Now he concentrated on explaining what he had learned from such experiments and from the entire history of scientific efforts to understand the phenomenology of visual space starting in the 19th century, when psychophysics and non-Euclidean geometry were both born in the same intellectual milieu. This led to two summary articles (Indow, 1997a, 1999) and to his final 2004 book. Tarow's starting point in the 1950s had been Luneberg's twin ideas that binocular spatial percepts can be modeled as geometrical objects in a three-dimensional Riemannian space of constant curvature (this based on intuitive axiomatic plausibility) and that experiments (originally by Blumenfeld in 1913, using a visual alley similar to Tarow's) established that the curvature is negative—meaning that visual space is not Euclidean, but rather Lobachevskian. Ultimately, Tarow rejected this idea as far too sweeping: many observations establish that the contents of visual space can alter its perceptual geometry. (“Visual space is not a solid container into which various percepts are placed without affecting the structure of the container”—Indow, 2004). But Luneberg's idea can still be correct, on a case-by-case basis, for visual space within a fixed setting involving a fixed set of objects. In particular, for visual-alley experiments where all the points lie on a common plane through the centers of the two eyes, Tarow's own careful replications of Blumenfeld's experiment showed that Luneberg's constant-negative-curvature model does generate accurate quantitative predictions, not just of the classic qualitative difference between “parallel” and “distance” alleys, but also of the exact shapes of the configurations produced by observers. Tarow's experiments also showed that a constant-curvature Riemannian model works for judgments of points located physically on a fronto-parallel plane; only there the curvature is zero. Tarow regarded these experimental results as demonstrating the value of retaining Luneberg's basic idea that visual space is generally Riemannian, but accepting that its curvature can vary across regions. (Here, the various planes are distinct 2-dimensional subspaces, with different local Gaussian curvatures.) His final book is really a lengthy, careful analysis of the viability of this idea. In the end he concludes that as long as we admit that visual space does have some geometrical qualities, it would be difficult to imagine them as not being at least locally and situationally Riemannian in a general sense; it is the job of experimentalists to determine the local parameters. One gets the sense that he did not regret having been beguiled by Luneberg's monograph in the Princeton bookstore so many years before.

The other topic that Tarow continued to pursue during retirement was color scaling—in particular, the old problem of finding a geometrical representation for the color sensations evoked by the Munsell chips. In total he published nearly two dozen articles on this topic. He was an early pioneer in applying multidimensional scaling to color appearance judgments of Munsell color chips, publishing between 1956 and 1962

half a dozen articles on the topic. By 2001 he had published another dozen articles on the topic of the appropriate geometrical representation of color appearance and had become recognized as the leading expert on color appearance systems as embodied in the Munsell and OSA Universal Color Scales atlases.

The new millennium added a new dimension to this work when Tarow began to apply multidimensional scaling methods to the physical reflectance spectra of the Munsell color chips and relating the results to his previous studies on the scaling properties of psychophysical judgments about the chips. This work, in collaboration with A.K. Romney, resulted in several joint publications. All were focused, in one way or another, on the natural question of the relationship between the geometrical representation of the physically measured reflectance spectra of the 1296 Munsell color chips and the previously obtained geometrical representations of perceptual judgments of the same chips. It soon became apparent that the scaling of the distances among the reflectance spectra of the chips could be well represented in three-dimensional Euclidean space (Romney & Indow, 2003b). Romney recalls that they were both excited by the fact that the Munsell reflectance spectra fit well into a Euclidean space. He remembers being amazed, when they first uncovered this fact, that despite Tarow's being on record as having concluded that color appearance is globally non-Euclidean, he said without hesitation, “It looks like it is Euclidean”. This project also investigated the reflectance spectra of natural surfaces. When these were included in the same analysis with Munsell chips, a fourth dimension had to be added to achieve the same very close fit afforded by a 3-dimensional model for the chips alone. Evidently the full chromatic world is somewhat more complex than Munsell's set of painted surfaces, but not much. The analysis also showed that the 3-dimensional structure dictated by the chips' spectral reflectance functions agrees closely with the structure of the sensory experiences they create, as revealed by applying the same multidimensional scaling analysis to perceptual judgments.

It is noteworthy, for this journal especially, that these fundamental results on the physical, as well as the psychological, side of color psychophysics were obtained with analytical methods invented and developed by mathematical psychologists and other social scientists. In the worldwide process of that scientific development, of course, Tarow played a key role.

Tarow continued this color work until the final few weeks of his life, with his last-but-one paper still under review at the time of his death (Indow & Romney, in press). His final article, then in preparation, lay on his desk—an unfinished manuscript together with the data and figures stacked neatly beside it. That paper, also collaborative with Romney, deals with a comparison of the reflectance spectra of a Japanese version of the Munsell atlas with the US version. His collaborator will see it through to completion.

Tarow's UCI colleagues recollect many things about him, but perhaps two unmistakable traits common to all were, first, his remarkably faithful attendance at the colloquia of both the Department of Cognitive Sciences and the Institute for Mathematical Behavioral Sciences. He by no means limited himself to vision talks, but was open to the broad range of social and behavioral science topics, in keeping with the underlying goals of, especially, the Institute. Often his questions revealed expertise and insight in areas one would not have expected. The second was his visits to one's office: a very polite greeting coupled with a formal Japanese bow, a well-focused and productive discussion, and his departure with another bow, followed by backing out of the office. And so it is with his intellectual contributions: formally precise, carefully thought out and communicated, always enlightening—and now, regrettably, concluded.

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Further reading

A complete list of Tarow Indow's English-language publications through 1992 is provided in his chapter in Luce et al. (1995) cited below. That bibliography also lists a few publications from 1993 and 1994. This bibliography supplements that one and brings it up to date. The two together provide a complete record.

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