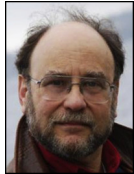


Reconsidering “The inappropriateness of conventional cephalometrics”



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Of all the articles on cephalometrics this journal has published over the last half-century, the one most cited across the scientific literature is the 1979 lecture “The inappropriateness of conventional cephalometrics” by Robert Moyers and me. But the durable salience of this article is perplexing, as its critique was misdirected (it should have been aimed at the craniometrics of the early twentieth century, not merely the roentgenographic extension used in the orthodontic clinic) and its proposed remedies have all failed to establish themselves as methods of any broad utility. When problems highlighted by Moyers and me have been resolved at all, the innovations that resolved them owe to tools very different from those suggested in our article and imported from fields quite a bit farther from biometrics than we expected back in 1979. One of these tools was the creation de novo of a new abstract mathematical construction, statistical shape space, in the 1980s and 1990s; another was a flexible and intuitive new graphic, the thin-plate spline, for meaningfully and suggestively visualizing a wide variety of biological findings in these spaces. On the other hand, many of the complaints Moyers and I enunciated back in 1979, especially those stemming from the disarticulation of morphometrics from the explanatory styles and purposes of clinical medicine, remain unanswered even today. The present essay, a retrospective historical meditation, reviews the context of the 1979 publication, its major themes, and its relevance today.

This essay is dedicated to the memory of Robert E. Moyers on the 100th anniversary of the *American Journal of Orthodontics and Dentofacial Orthopedics*. (Am J Orthod Dentofacial Orthop 2016;149:784-97)

The inappropriateness of conventional cephalometrics,” a lecture by Robert E. Moyers (1919–1996) and me that this journal published in 1979,¹ remains its most cited article on cephalometrics of the last 50 years. Its title, though intentionally provocative, was not an exaggeration, and its argument, viewed from 37 years on, can still be viewed as a daring piece of intellectual criticism. From Moyers’ point of view it must have felt like a pitiless intellectual self-portrait, an explicit and mostly destructive critique of the biostatistical methodology embraced by the clinical profession (orthodontics) that he had served as an academic chairman for 15 years and then as the

director of an even more interdisciplinary research center (craniofacial growth and development) for 15 years more (McNamara²).

The citation history of this article differs strikingly from the early-peaking, long-tailing shape that constitutes the commonest form of citation history for peer-reviewed biomedical articles in primary research journals. As Figure 1 shows, “Inappropriateness” (as I will be referring to this paper in these pages, for brevity) has been cited steadily, though irregularly, throughout the whole time span since its appearance. The year of peak citation count, in fact, was 2002, nearly a quarter of a century after its publication and 6 years after the death of its senior author, and it was cited as many times in 2014 as it was in 1982 or 1983. The article is actually the senior author’s most cited journal publication (though of course there are far more citations to his celebrated textbook of orthodontics) and also serves as my own most cited paper on any aspect of skeletal or craniofacial biology. Those who were present at its original presentation (the Cordwainers Lecture, Institute of

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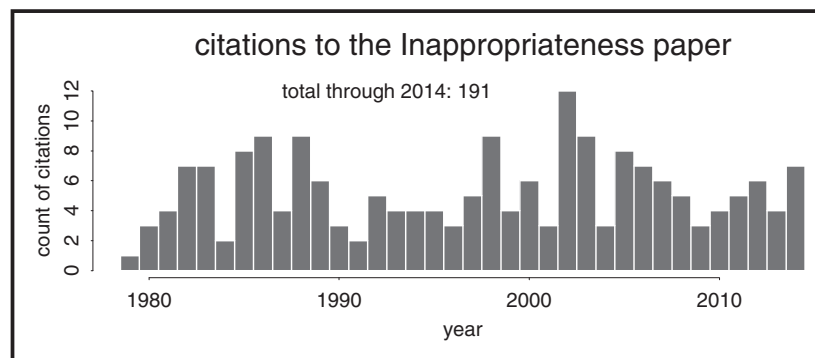


Fig 1. Citation history of “Inappropriateness.”¹ Data from the Thomson-Reuters Web of Science, retrieved on June 19, 2015.

Dental Surgery, University of London, May 17, 1978) surely numbered dozens more.

In addition to this odd stability of citation frequency, or perhaps in spite of it, “Inappropriateness” is unusual for 2 other reasons. As I already hinted, it objects to the methodology of nearly everything else that its senior author had been publishing recently, including the long-awaited and widely distributed *Atlas of Craniofacial Growth*³ that had appeared just a few years earlier after an enormous effort of compilation; and every methodological resolution that it prophesied for the problems and infelicities it diagnosed proved just about as inappropriate as the conventional methods that were pilloried in its own pages.

Whereas I was the brash young applied mathematician (less than two years past my own Ph.D.) slashing through the lore of an established field (clinical orthodontics) in which I had neither training nor professional stake, Moyers had committed decades of his career to publications based in just the quantitative language regarding which he had already turned skeptical, a language I seemed to be trying to demolish. But the proposed upgrades of method I could offer Moyers’ readers at the time “Inappropriateness” was written did not last even 5 years. Already by 1984, for instance, biorthogonal grids, the core technique of my doctoral dissertation,⁴ had been replaced by the shape coordinates (see below) that proved far more suitable for statistical summaries such as variance and covariance. So my co-author had far more status at risk than I had, and yet his contributions to the radical part of the argument proved far more cogent than mine. Of the systematic charges that “Inappropriateness” laid against conventional cephalometrics—I will review them below under the paper’s own rubrics of “fabrication,” “camouflage,” “confusion,” and “subtraction”—some remain unresolved to this day, while those that have been resolved owe their resolution not to the techniques named as promising

in the same lecture—representations of curvature, medial axes, and biorthogonal grids—but to innovations arising from other branches of biometrics and medical image analysis entirely: the class of methods that are nowadays generally referred to as geometric morphometrics (GMM).

That was not what I expected the fate of this paper to be. I had not properly understood its own academic context, which was not the setting of craniofacial biology into which Moyers had inducted me when he appointed me assistant research scientist in his Center for Human Growth and Development at the University of Michigan in 1977, but the much older context of anthropometry and in particular craniometry* that had been under relatively unsupervised development since at least the turn of the twentieth century. That “there is no theory of cephalometrics,” as “Inappropriateness” cogently argues, is because there was not and never had been any proper methodology of craniometrics either. The channels of “misinformation” that “Inappropriateness” unearthed were entirely exogenous in their origin: the combination of problems pervading all of twentieth-century craniometry with the newer ambiguities of a

*In this essay I will use the word “craniometry” in the orthodontist’s sense—the measurement of the cephalogram, the conventionally positioned lateral or anteroposterior roentgenogram. “Craniometry” or “craniometrics,” after the German or French, will instead mean the measurement of the solid skull as an object in the laboratory or, more recently, its virtualized equivalent as a 3-dimensional surface image. One hundred years ago the word “craniometry” already appeared in the standard unabridged dictionaries of educated English. For instance, on page 1331 of the 8600-page *Century Dictionary* of 1914,⁵ under this keyword, there is a thousand-word entry mentioning and displaying dozens of points and lines that might have served as a précis of Rudolf Martin’s textbook⁶ of the same year. At this time the word “cephalometrics” apparently did not even exist as a technical term in English. The closest my *Century Dictionary* comes is the 4-word entry on page 891 under “cephalometry”: “measurement of the head.” This follows the entry for “cephalometer,” which is “an instrument formerly used for measuring the fetal head during parturition.” As used in this essay, then, the word “cephalometrics” is a neologism postdating the development of the standardized roentgenography on which it is based (the Broadbent-Bolton imaging instrument of 1937).

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