

# Richard Harshman: A man of ideas

*N. D. Sidiropoulos*

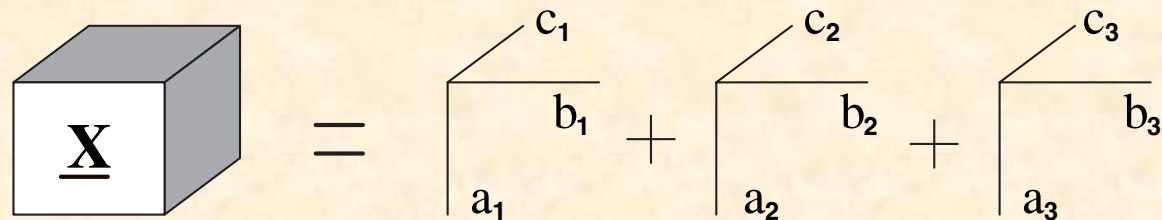
Dept ECE & TSI  
Technical University of Crete  
Greece

# Richard Harshman



© Pieter Kroonenberg

# PARAFAC



F.L. Hitchcock, "The expression of a tensor or a polyadic as a sum of products," *Journal of Mathematical Physics* vol. 6, pp. 164–189, 1927.

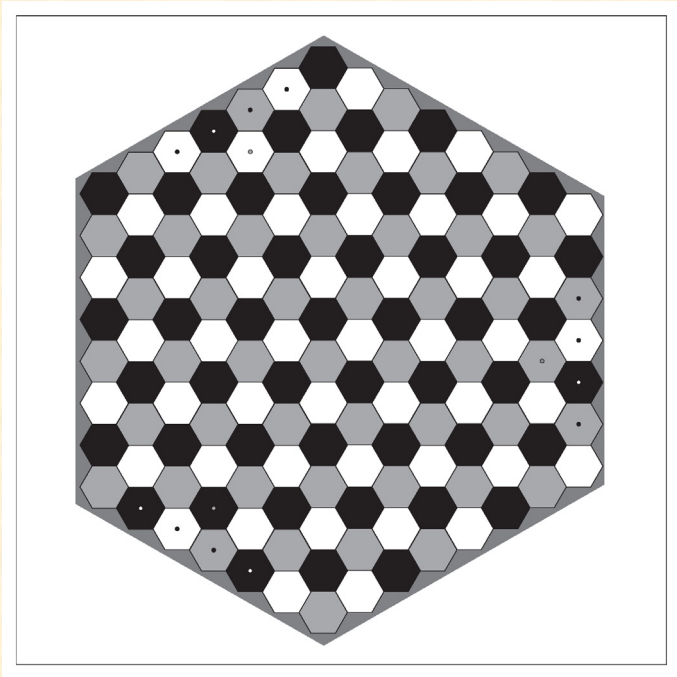
R. Cattell, "Parallel proportional profiles and other principles for determining the choice of factors by rotation," *Psychometrika*, vol. 9, no. 4, pp. 267–283, Dec. 1944.

**R. A. Harshman, "Foundations of the PARAFAC procedure: Model and conditions for an 'explanatory' multi-mode factor analysis," *UCLA Working Papers in Phonetics*, vol. 16, pp. 1–84, 1970.**

J.D. Carroll, J.J. Chang, Analysis of individual differences in multidimensional scaling via an  $n$ -way generalization of Eckart–Young decomposition, *Psychometrika*, vol. 35, pp. 283–319, 1970.

J. B. Kruskal, "Three-way arrays: Rank and uniqueness of trilinear decompositions, with application to arithmetic complexity and statistics," *Linear Algebra Appl.*, vol. 18, pp. 95–138, 1977.

# Three-way chess!

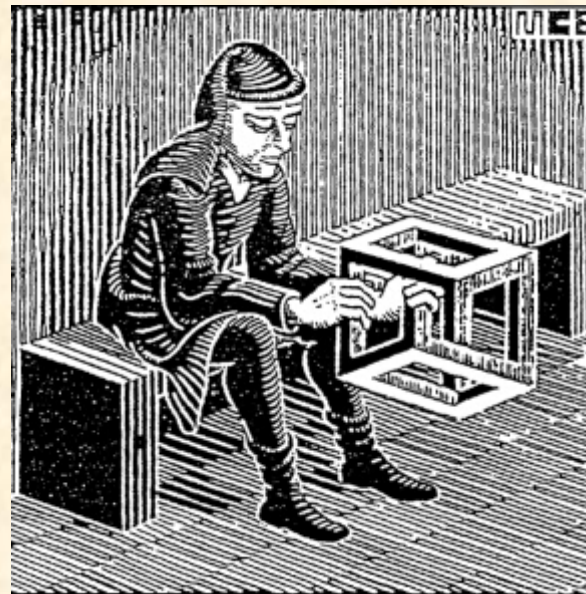


# Richard's Research

- PARAFAC
- DEDICOM
- LSA (Latent Semantic Analysis)
- SFA (Shifted Factor Analysis) ...
- GCC (Generalized Canonical Correlation Analysis) ...
- ... w/ applications in psychometrics, chemometrics, cognition, neuropsychology, ...



# In a nutshell ... Richard was a true



**Three-Mode Data Analyst:**  
officially called *Man with Cuboid*, © The  
M.C. Escher Company

# Richard's legacy

- [http://en.wikipedia.org/wiki/Richard\\_Harshman](http://en.wikipedia.org/wiki/Richard_Harshman)

Dr **Richard A. Harshman** was a member of the Department of Psychology of the University of Western Ontario since 1976, rising in the ranks to the level of Full Professor. He died suddenly in January 2008. He was one of the pioneers of Latent semantic analysis. He made important contributions in Psychometrics including the analysis of asymmetric square tables and the analysis multiway tables. His work on parallel factor analysis (PARAFAC) is used in biomedical applications, Chemometrics, and Wireless communications.

- $h$ -index = 31 (as of June 2009, via Google Scholar)
- Most influential papers?

## Richard's legacy

- *Deerwester, S., Dumais, S. T., Furnas, G. W., Landauer, T. K., & Harshman, R. A. (1990). **Indexing by latent semantic analysis**. *Journal of the American Society for Information Science*, 41, 391-407. (4,141 citations!)*
- Harshman, R. A. (1970). Foundations of the **PARAFAC** procedure: Models and conditions for an "explanatory" multi-modal factor analysis. *UCLA Working Papers in Phonetics*, 16, 1-84. (UMI Serials in Microform, No. 10,085). (538 citations)
- Over 7000 citations in all



# J. Chemometrics SI

*in memory of R.A. Harshman*

- [Kiers, Henk](#), An Efficient Algorithm for PARAFAC with Uncorrelated Mode-A Components Applied to  $I \times J \times K$  data with  $I \gg JK$
- [Lundy, Margaret](#), Richard A. Harshman (1943-2008), A Man of Ideas
- [Hong, Sungjin](#), Warped Factor Analysis
- [Comon, Pierre](#), Tensor Decompositions, Alternating Least Squares and other Tales
- [Takane, Yoshio](#), Algorithms for DEDCOM: Acceleration, Deceleration, or Neither
- [Synovec, Robert](#), Toward automated peak resolution in complete  $GC \times GC$ -TOFMS chromatograms by PARAFAC
- [Morten, Morup](#), Automatic Relevance Determination for Multi-way Models
- [Verouden, Maikel](#), Multi-way analysis of flux distributions across multiple conditions.
- [Lim, Lek-Heng](#), Nonnegative approximations of nonnegative tensors
- [Papy, Jean-Michel](#), Exponential Data Fitting Using Multilinear Algebra: The Decimative Case
- [Ten Berge, Jos](#), The link between sufficient conditions by Harshman and by Kruskal for uniqueness in Candecomp/Parafac.
- [Bro, Rasmus](#), Modeling Multi-Way Data with Linearly Dependent Loadings
- [Stegeman, Alwin](#), Using the Simultaneous Generalized Schur Decomposition as a Candecomp/Parafac algorithm for ill-conditioned data
- [Sidiropoulos, Nikos](#), Editorial: In memory of Richard Harshman