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Advances in Survival Analysis and Optimal Scaling Methods

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BIBLIOGRAPHY

- Ajzen, I. *The theory of planned behaviour*. Organisational behaviour and human decision processes, 50:179–211, 1991. – Cited on page 55.
- Andersen, P. K. and Gill, R. D. *Cox's Regression Model for Counting Processes: A Large Sample Study*. The Annals of Statistics, 10(4):1100–1120, 1982. – Cited on page 33.
- Bender, R., Augustin, T., and Blettner, M. *Generating survival times to simulate Cox proportional hazards models*. Statistics in Medicine, 24(11):1713–1723, 2005. – Cited on page 38.
- Boršič, D. and Kavkler, A. *Modeling unemployment duration in Slovenia using Cox regression models*. Transition Studies Review, 16(1):145–156, 2009. – Cited on page 45.
- Boyle, C. M. *Difference Between Patients' and Doctors' Interpretation of Some Common Medical Terms*. British Medical Journal, 2(5704):286–289, 1970. – Cited on page 140.
- Breslow, N. E. *Contribution to the Discussion of Paper by D.R. Cox*. Journal of the Royal Statistical Society. Series B (Methodological), 34:216–217, 1972. – Cited on pages 81 and 99.
- Brouwer, S., Bakker, R. H., and Schellekens, J. M. H. *Predictors for re-employment success in newly unemployed: A prospective cohort study*. Journal of Vocational Behaviour, 89:32–38, 2015. – Cited on pages 46, 47, 51, and 53.
- Bryant, G. D. and Norman, G. R. *Expressions of probability: words and numbers*. New England Journal of Medicine, 302(7):411, 1980. – Cited on pages 136 and 140.
- Budescu, D. V. and Wallsten, T. S. *Consistency in interpretation of probabilistic phrases*. Organizational Behavior and Human Decision Processes, 36(3):391–405, 1985. – Cited on page 136.

- Castro, C. M., Wilson, C., Wang, F., and Schillinger, D. *Babel babble: Physicians' use of unclarified medical jargon with patients*. *American Journal of Health Behavior*, 31(Suppl 1):S85–95, 2007. – Cited on page 140.
- Chang, I. M., Gelman, R., and Pagano, M. *Corrected group prognostic curves and summary statistics*. *Journal of Chronic Diseases*, 35(8):669 – 674, 1982. ISSN 0021-9681. – Cited on page 30.
- Cox, D. R. *Regression Models and Life Tables (with Discussion)*. *Journal of the Royal Statistical Society B*, 34:187–220, 1972. – Cited on pages 8 and 53.
- Davidson, R. A. and Chrisman, H. H. *Translations of uncertainty expressions in Canadian accounting and auditing standards*. *Journal of International Accounting, Auditing and Taxation*, 3(2):187 – 203, 1994. – Cited on page 137.
- Doupnik, T. S. and Richter, M. *Interpretation of uncertainty expressions: a cross-national study*. *Accounting, Organizations and Society*, 28(1):15 – 35, 2003. – Cited on page 137.
- Druzdzel, M. J. *Verbal Uncertainty Expressions: Literature Review*. Technical Report, 1989. – Cited on pages 10, 136, 138, and 140.
- Eekhof, J. A. H., Mol, S. S. L., and Pielage, J. C. *Is doorgaans vaker dan dikwijls; of hoe vaak is soms?* *Nederlands Tijdschrift voor Geneeskunde*, 136(1):41, 1992. – Cited on pages 137, 141, 142, and 151.
- Erev, I. and Cohen, B. L. *Verbal versus Numerical Probabilities: Efficiency, Biases, and the Preference Paradox*. *Organizational Behavior and Human Decision Processes*, 45:1–18, 1990. – Cited on page 138.
- European Food Safety Authority, Hart, A., Maxim, L., Siegrist, M., da Cruz, C., Merten, C., Lahaniatis, M., and Smith, A. *Outcome of the Public Consultation on the draft Guidance on Communication of Uncertainty in Scientific Assessments*. *EFSA Journal*, 17(1):1–73, 2019. – Cited on page 136.
- Fox, J. and Carvalho, M. S. *The RcmdrPlugin.survival Package: Extending the R Commander Interface to Survival Analysis*. *Journal of Statistical Software*, 49(7):1–32, 2012. – Cited on page 34.
- Friedman, J. H. and Stuetzle, W. *Projection Pursuit Regression*. *Journal of the American Statistical Association*, 76(376):817–823, 1981. – Cited on pages 102 and 105.
- Gifi, A. *Nonlinear Multivariate Analysis*. John Wiley & Sons, Ltd., 1990. Original work published 1981. – Cited on pages 9, 69, 102, and 105.

- Google. *Google Translate*. <https://translate.google.com>, June 2018. – Cited on page 141.
- Graf, E., Schmoor, C., Sauerbrei, W., and Schumacher, M. *Assessment and comparison of prognostic classification schemes for survival data*. *Statistics in Medicine*, 18:2529 – 2545, 1999. – Cited on page 65.
- Green, P. J. *Iteratively Reweighted Least Squares for Maximum Likelihood Estimation, and some Robust and Resistant Alternatives*. *Journal of the Royal Statistical Society: Series B*, 46(2):149–192, 1984. – Cited on page 99.
- Harrell, F. E., Lee, K. L., and Mark, D. B. *Multivariable prognostic models: issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors*. *Statistics in Medicine*, 15:361–387, 1996. – Cited on page 65.
- Harris, A. J. L., Corner, A., Xu, J., and Du, X. *Lost in translation? Interpretations of the probability phrases used by the Intergovernmental Panel on Climate Change in China and the UK*. *Climatic Change*, 121(2):415–425, 2013. – Cited on page 137.
- Hartmann, A., Van der Kooij, A. J., and Zeeck, A. *Exploring nonlinear relations: Models of clinical decision making by regression with optimal scaling*. *Psychotherapy Research*, 19(4-5):482–492, 2009. – Cited on page 115.
- Hastie, T. J. and Tibshirani, R. J. *Generalized Additive Models*. *Monographs on Statistics & Applied Probability*. Chapman & Hall/CRC, 1990. – Cited on pages 102, 105, and 131.
- Jenkins, S. C., Harris, A. J. L., and Lark, R. M. *Understanding ‘Unlikely (20% Likelihood)’ or ‘20% Likelihood (Unlikely)’ Outcomes: The Robustness of the Extremity Effect*. *Journal of Behavioural Decision Making*, 31, 2018. – Cited on page 152.
- Jolliffe, I. T. *Principal component analysis*. New York, NY: Springer-Verlag, 2002. – Cited on page 52.
- Juanchich, M. and Sirota, M. *Do people really prefer verbal probabilities?* *Psychological Research*, Jun 2019. – Cited on page 138.
- Kaplan, E. L. and Meier, P. *Nonparametric Estimation from Incomplete Observations*. *Journal of the American Statistical Association*, 53:457–481, 1958. – Cited on pages 15 and 35.



- Kavkler, A., Dănaćică, D. E., Babucea, A. G., Bićanić, I., Böhm, B., Tevdovski, D., Toševska, K., and Boršič, D. *Cox regression models for unemployment duration in Romania, Austria, Slovenia, Croatia, and Macedonia*. Romanian Journal of Economic Forecasting, 10(2):81–104, 2009. – Cited on page 45.
- Kim, Y., Kim, J., and Kim, Y. *Blockwise Sparse Regression*. Statistica Sinica, 16(2):375–390, 2006. – Cited on page 132.
- Klein, J. P. and Moeschberger, M. L. *Survival Analysis: Techniques for Censored and Truncated Data*. Statistics for Biology and Health. Springer, second edition edition, 2003. – Cited on pages 53 and 71.
- Kleinbaum, D. G. and Klein, M. *Survival Analysis: A Self-Learning Text*. Statistics for Biology and Health. Springer, third edition edition, 2012. – Cited on page 16.
- Kruskal, J. B. *Nonmetric multidimensional scaling: a numerical method*. Psychometrika, 29:115–129, 1964. – Cited on pages 74, 78, 103, and 106.
- Lichtenstein, S. and Newman, J. R. *Empirical scaling of common verbal phrases associated with numerical probabilities*. Psychonomic Science, 9(10):563–564, 1967. – Cited on pages 10, 138, and 139.
- Lim, T. S., Loh, W. Y., and Shih, Y. S. *A Comparison of Prediction Accuracy, Complexity, and Training Time of Thirty-Three Old and New Classification Algorithms*. Machine Learning, 40(3):203–228, Sep 2000. – Cited on page 120.
- Linting, M. and van der Kooij, A. *Nonlinear Principal Components Analysis With CATPCA: A Tutorial*. Journal of Personality Assessment, 94(1):12–25, 2012. – Cited on pages 52, 54, and 55.
- Linting, M., Meulman, J. J., Groenen, P. J., and van der Kooij, A. J. *Nonlinear principal components analysis: introduction and application*. Psychological Methods, 12(3):336–358, September 2007. – Cited on pages 44, 52, 70, and 95.
- MacLeod, A. and Pietravalle, S. *Communicating risk: variability of interpreting qualitative terms*. EPPO Bulletin, 47(1):57–68, 2017. – Cited on page 140.
- McCullagh, P. and Nelder, J. A. *Generalized Linear Models*. Monographs on Statistics & Applied Probability. Chapman & Hall/CRC, 1989. – Cited on pages 9 and 102.
- Meulman, J. J., Van der Kooij, A. J., and Heiser, W. J. *Principal components analysis with nonlinear optimal scaling transformations for ordinal and nominal data*. In Kaplan, D., editor, *Handbook of Quantitative Methodology for the*

- Social Sciences.*, pages 49–70. Sage, London, 2004. – Cited on pages 10, 44, 52, 70, and 95.
- Meulman, J. J., Van der Kooij, A. J., and Duisters, K. L. W. *ROS Regression: Integrating Regularization with Optimal Scaling Regression*. *Statistical Science*, 34:361–390, 2019. – Cited on pages 9, 70, 75, 104, and 132.
- Montgomery, S. A. and Åsberg, M. *A new depression scale designed to be sensitive to change*. *The British Journal of Psychiatry*, 134(4):382–9, 1979. – Cited on page 22.
- Mooney, C. Z. *Monte Carlo Simulation (Quantitative Applications in the Social Sciences)*. SAGE Publications, April 1997. ISBN 0803959435. – Cited on page 38.
- Mosteller, F. and Youtz, C. *Quantifying Probabilistic Expressions*. *Statistical Science*, 5(1):2–12, 1990. – Cited on pages 139, 140, and 146.
- Pander Maat, H. and Klaassen, R. *De invloed van de formulering van informatie over bijwerkingen op interpretaties door patiënten en op gemelde bijwerkingen*. *Nederlands Tijdschrift voor Geneeskunde*, 140(8):424–427, 1996. – Cited on pages 137, 139, 140, and 141.
- Putter, H., Fiocco, M., and Geskus, R. B. *Tutorial in biostatistics: competing risks and multi-state models*. *Statistics in Medicine*, 26(11):2389–2430, 2007. – Cited on page 53.
- Qualtrics. *Qualtrics*. <https://www.qualtrics.com>, 2005-2018. – Cited on page 143.
- R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2018. URL <https://www.R-project.org/>. – Cited on pages 11, 18, and 114.
- Ramsay, J. O. *Monotone Regression Splines in Action*. *Statistical Science*, 3(4): 425–442, November 1988. – Cited on pages 75, 103, and 106.
- Reagan, R. T., Mosteller, F., and Youtz, C. *Quantitative meanings of verbal probability expressions*. *Journal of Applied Psychology*, 74(3):433–442, 1989. – Cited on pages 10, 137, 138, and 139.
- Renooij, S. and Witteman, C. *Talking probabilities: communicating probabilistic information with words and numbers*. *International Journal of Approximate Reasoning*, 22(3):169–194, 1999. – Cited on pages 137 and 141.



- Robins, J. M. *Information Recovery and Bias Adjustment in Proportional Hazards Regression Analysis of Randomized Trials Using Surrogate Markers*. Proceedings of the Biopharmaceutical Section, American Statistical Association, pages 24–33, 1993. – Cited on pages 14 and 16.
- Robins, J. M. and Finkelstein, D. M. *Correcting for Noncompliance and Dependent Censoring in an AIDS Clinical Trial with Inverse Probability of Censoring Weighted (IPCW) Log-Rank Tests*. *Biometrics*, 56:779–788, 2000. – Cited on pages 14, 16, and 18.
- Robins, J. M. and Rotnitzky, A. *Recovery of Information and Adjustment for Dependent Censoring Using Surrogate Markers*. In Jewell, N. P., Dietz, K., and Farewell, V. T., editors, *AIDS Epidemiology*, pages 297–331. Birkhäuser Boston, 1992. ISBN 978-1-4757-1231-5. – Cited on pages 14 and 16.
- Simon, N., Friedman, J., Hastie, T., and Tibshirani, R. *Regularization Paths for Cox’s Proportional Hazards Model via Coordinate Descent*. *Journal of Statistical Software*, 39(5):1–13, 2011. – Cited on pages 80, 81, 97, 99, and 109.
- SPSS Inc. *SPSS Statistics for Windows, Version 17.0*. Chicago, 2008. – Cited on page 52.
- Stheeman, S. E., Mileman, P. A., van ’t Hof, M. A., and van der Stelt, P. F. *Blind chance? An investigation into the perceived probabilities of phrases used in oral radiology for expressing chance*. *Dento maxillo facial radiology*, 22:135–139, 1993. – Cited on pages 10, 139, and 140.
- Takane, Y., Young, F. W., and de Leeuw, J. *The principal components of mixed measurement level multivariate data: An alternating least squares method with optimal scaling features*. *Psychometrika*, 49:279–281, 1978. – Cited on page 10.
- Theil, M. *The role of translations of verbal into numerical probability expressions in risk management: a meta-analysis*. *Journal of Risk Research*, 5(2):177–186, 2002. – Cited on pages 136, 140, 141, 151, and 152.
- Therneau, T. M. *A Package for Survival Analysis in S*, 2013. URL <http://CRAN.R-project.org/package=survival>. R package version 2.37-4. – Cited on pages 14 and 18.
- Therneau, T. M. and Grambsch, P. M. *Modeling Survival Data: Extending the Cox Model*. Springer, New York, 2000. – Cited on pages 14 and 18.
- Timmermans, D. *The Roles of Experience and Domain of Expertise in Using Numerical and Verbal Probability Terms in Medical Decisions*. *Medical Decision Making*, 14:146–156, 1994. – Cited on pages 137, 141, and 142.

- Timmermans, D. R. M. and Mileman, P. A. *Lost for words: using verbal terms to express probabilities in oral radiology*. *Dento maxillo facial radiology*, 22(4): 171–172, 1993. – Cited on page 139.
- Tutkun, N. A. and Karasoy, D. *Applying frailty models to analyse the duration of unemployment in Turkey*. *International Journal of Statistics & Economics*, 17(2):44–57, 2016. – Cited on page 45.
- Twitter Inc. *Twitter*. <https://twitter.com>, 2018. – Cited on page 144.
- Van Dale Uitgevers. *Van Dale*. <https://www.vandale.nl>, June 2018. – Cited on page 141.
- Van der Kooij, A. J. *Prediction Accuracy and Stability of Regression with Optimal Scaling Transformations*. PhD thesis, Leiden University, 2007. – Cited on page 104.
- Van der Kooij, A. J. and Meulman, J. J. *Regression with Optimal Scaling*. In Meulman, J., Heiser, W., and Inc., S., editors, *SPSS Categories 10.0.*, pages 1–8, 77–101, 239–246. Chicago: SPSS Inc, 1999. – Cited on pages 9, 52, and 102.
- van Swieten, J. C., Koudstaal, P. J., Visser, M. C., Schouten, H. J., and van Gijn, J. *Interobserver agreement for the assessment of handicap in stroke patients*. *Stroke*, 19:604–607, 1988. – Cited on page 68.
- Venhuizen, G. J., Hut, R., Albers, C., Stoof, C. R., and Smeets, I. *Flooded by jargon: how the interpretation of water-related terms differs between hydrology experts and the general audience*. *Hydrology and Earth System Sciences*, 2019. Accepted for publication. – Cited on page 140.
- Visschers, V. H. M., Meertens, R. M., Passchier, W. W. F., and de Vries, N. N. K. *Probability Information in Risk Communication: A Review of the Research Literature*. *Risk Analysis*, 29(2):267–287, 2009. – Cited on page 136.
- Vroom, V. H. *Work and motivation*. John Wiley & Sons, New York, 1964. – Cited on page 55.
- Wallsten, T. S., Fillenbaum, S., and Cox, J. A. *Base rate effects on the interpretations of probability and frequency expressions*. *Journal of Memory and Language*, 25(5):571–587, 1986. – Cited on pages 11 and 140.
- Wanberg, C. R., Hough, L. M., and Song, Z. *Predictive validity of a multidisciplinary model of re-employment success*. *Journal of Applied Psychology*, 85: 1100–1120, 2002. – Cited on page 45.



- Weber, E. U. and Hilton, D. J. *Contextual Effects in the Interpretations of Probability Words: Perceived Base Rate and Severity of Events*. *Journal of Experimental Psychology: Human Perception and Performance*, 16(4):781–789, 1990. – Cited on pages 139 and 140.
- Wijnhoven, M. A. and Havinga, H. *The Work Profiler: A digital instrument for selection and diagnosis of the unemployed*. *Local Economy*, 29(6-7):740–749, 2014. – Cited on page 46.
- Willems, S. J. W., Fiocco, M., and Meulman, J. J. *Optimal scaling for survival analysis with ordinal data*. *Computational Statistics & Data Analysis*, 115:155 – 171, 2017. – Cited on page 109.
- Winsberg, S. and Ramsay, J. O. *Monotonic transformations to additivity using splines*. *Biometrika*, 67(3):669–674, 1980. ISSN 0006-3444. – Cited on page 102.
- Wintle, B. C., Fraser, H., Wills, B. C., Nicholson, A. E., and Fidler, F. *Verbal probabilities: Very likely to be somewhat more confusing than numbers*. *PLoS ONE*, 14(4):1–18, 04 2019. – Cited on page 152.
- Yang, Y. and Zou, H. *A cocktail algorithm for solving the elastic net penalized Cox’s regression in high dimensions*. *Statistics and Its Interface*, 6:167–173, 2013. – Cited on page 85.
- Young, F. W. *Quantitative analysis of qualitative data*. *Psychometrika*, 46(4): 357–388, 1981. – Cited on page 102.
- Young, F. W., de Leeuw, J., and Takane, Y. *Regression with qualitative and quantitative variables: An alternating least squares method with optimal scaling features*. *Psychometrika*, 41:505–528, December 1976. – Cited on pages 9, 102, and 105.
- Yuan, M. and Lin, Y. *Model Selection and Estimation in Regression With Grouped Variables*. *Journal of the Royal Statistical Society: Series B*, 68:49–67, 02 2006. – Cited on page 132.
- Zeeck, A., Hartmann, A., Küchenhoff, J., Weiss, H., Sammet, I., Gaus, E., Semm, E., Harms, D., Eisenberg, A., Rahm, R., and von Wietersheim, J. *Differenzielle Indikationsstellung stationärer und tagesklinischer Psychotherapie: die DINSTAP-Studie[1]*. *Psychotherapie, Psychosomatik, Medizinische Psychologie*, 59(9/10):354–363, 2009. – Cited on page 115.

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