Causes and effects in Dichotomous Comparative Judgments: an information-theoretical system of plausible mechanism

Jose Manuel Rivera Espejo[a,*], Tine van Daal[a], Sven De Maeyer[a], Steven Gillis[b]

[a] *University of Antwerp, Training and education sciences,*

[b] *University of Antwerp, Linguistics,*

Abstract

(to do)

Keywords: causal inference, probability, Thurstone, comparative judgement, directed acyclic graph, structural causal models, statistical modeling

1. Introduction

Over the past decade, numerous studies have documented the effectiveness of the *comparative judgment* (CJ) method (Thurstone, 1927; Pollitt, 2012a) for assessing competencies and traits. These studies have evaluated CJ from two main perspectives: its ability to produce reliable and valid trait scores, and its practical applicability. In terms of reliability and validity, research has shown that CJ can generate precise and consistent scores that accurately represent the traits being measured. Notable contributions in this research area include studies by Pollitt (2012b), Whitehouse (2012), van Daal et al. (2019a), Lesterhuis (2018), van Daal et al. (2019b), Bramley and Vitello (2019), Verhavert et al. (2019), Crompvoets et al. (2022), and Bouwer et al. (2023). Regarding practical applicability, several studies have highlighted the method's versatility in both educational and non-educational contexts, presenting it as an efficient and effective alternative for measurement and evaluation. Key examples in this research area include the works of Jones (2015), Bartholomew et al. (2018), Jones et al. (2019), Marshall et al. (2020), Bartholomew and Williams (2020), and Boonen et al. (2020).

Nevertheless, despite the growing number of CJ studies, the research approaches employed in the literature have been unsystematic and non-integrated, leading to the oversight of several critical issues related to the method. These issues include concerns about the measurement model responsible for generating the CJ scores, the structural component used for further data analysis and hypothesis testing, and challenges related to the

*Corresponding author

Email addresses: JoseManuel.RiveraEspejo@uantwerpen.be (Jose Manuel Rivera Espejo), tine.vandaal@uantwerpen.be (Tine van Daal), sven.demaeyer@uantwerpen.be (Sven De Maeyer), steven.gillis@uantwerpen.be (Steven Gillis)

design of CJ experiments. For instance, a notable concern regarding the measurement model is the prevalent reliance on the assumptions of Case 5 from Thurstone's law of comparative judgment (1927). Although Case 5 was originally articulated to produce a "rough measurement" or "rather coarse scaling" of traits (Thurstone, 1927, p. 268-269), its assumptions have become predominant in the literature due to its implementation through the Bradley-Terry-Luce (BTL) model (Bradley and Terry, 1952; Luce, 1959). This leaves issues such as the presence of judge' biases hinted by Bramley (2008) and Kelly et al. (2022), and evidenced by Pollitt and Elliott (2003), **?**, and **?**

2. Theory

2.1. Let's talk about Thurstone co.

2.2. A scientific model for the CJ

2.3. From theory to statistical model

3. Discussion

3.1. Findings

3.2. Limitations and further research

4. Conclusion

Declarations

Funding: The project was founded through the Research Fund of the University of Antwerp (BOF).

Financial interests: The authors have no relevant financial interest to disclose.

Non-financial interests: Author XX serve on advisory broad of Company Y but receives no compensation this role.

Ethics approval: The University of Antwerp Research Ethics Committee has confirmed that no ethical approval is required.

Consent to participate: Not applicable

Consent for publication: All authors have read and agreed to the published version of the manuscript.

Availability of data and materials: No data was utilized in this study.

Code availability: All the code utilized in this research is available in the digital document located at: https://jriveraespejo.github.io/paper2_manuscript/.

Authors' contributions: *Conceptualization:* S.G., S.DM., T.vD., and J.M.R.E; *Methodology:* S.DM., T.vD., and J.M.R.E; *Software:* J.M.R.E.; *Validation:* J.M.R.E.; *Formal Analysis:* J.M.R.E.; *Investigation:* J.M.R.E; *Resources:* S.G., S.DM., and T.vD.; *Data curation:* J.M.R.E.; *Writing - original draft:* J.M.R.E.; *Writing - review & editing:* S.G., S.DM., and T.vD.; *Visualization:* J.M.R.E.; *Supervision:* S.G. and S.DM.; *Project administration:* S.G. and S.DM.; *Funding acquisition:* S.G. and S.DM.

5. Appendix

References

Bartholomew, S., Nadelson, L., Goodridge, W., Reeve, E., 2018. Adaptive comparative judgment as a tool for assessing open-ended design problems and model eliciting activities. Educational Assessment 23, 85–101. doi:10.1080/10627197.2018.1444986.

Bartholomew, S., Williams, P., 2020. Stem skill assessment: An application of adaptive comparative judgment, in: Anderson, J., Li, Y. (Eds.), Integrated Approaches to STEM Education. Advances in STEM Education. Springer, pp. 331–349. doi:10.1007/978-3-030-52229-2_18.

Boonen, N., Kloots, H., Gillis, S., 2020. Rating the overall speech quality of hearing-impaired children by means of comparative judgements. Journal of Communication Disorders 83, 1675–1687. doi:10.1016/j.jcomdis.2019.105969.

Bouwer, R., Lesterhuis, M., De Smedt, F., Van Keer, H., De Maeyer, S., 2023. Comparative approaches to the assessment of writing: Reliability and validity of benchmark rating and comparative judgement. Journal of Writing Research 15, 497–518. URL: https://www.jowr.org/index.php/jowr/article/view/867, doi:10.17239/jowr-2024.15.03.03.

Bradley, R., Terry, M., 1952. Rank analysis of incomplete block designs: I. the method of paired comparisons. Biometrika 39, 324–345. URL: http://www.jstor.com/stable/2334029, doi:10.2307/2334029.

Bramley, T., 2008. Paired comparison methods, in: Newton, P., Baird, J., Goldsteing, H., Patrick, H., Tymms, P. (Eds.), Techniques for monitoring the comparability of examination standards. GOV.UK., pp. 246—300. URL: https://www.gov.uk/government/publications/techniques-for-monitoring-the-comparability-of-examination-standards.

Bramley, T., Vitello, S., 2019. The effect of adaptivity on the reliability coefficient in adaptive comparative judgement. Assessment in Education: Principles, Policy and Practice 71, 1–25. doi:10.1080/0969594X.2017.1418734.

Crompvoets, E.A.V., Béguin, A.A., Sijtsma, K., 2022. On the bias and stability of the results of comparative judgment. Frontiers in Education 6. URL: url{https://www.frontiersin.org/articles/10.3389/feduc.2021.788202}, doi:10.3389/feduc.2021.788202.

Jones, I., 2015. The problem of assessing problem solving: can comparative judgement help? Educational Studies in Mathematics 89, 337–355. doi:10.1007/s10649-015-9607-1.

Jones, I., Bisson, M., Gilmore, C., Inglis, M., 2019. Measuring conceptual understanding in randomised controlled trials: Can comparative judgement help? British Educational Research Journal 45, 662–680. URL: https://bera-journals.onlinelibrary.wiley.com/doi/abs/10.1002/berj.3519, doi:10.1002/berj.3519.

Kelly, K., Richardson, M., Isaacs, T., 2022. Critiquing the rationales for using comparative judgement: a call for clarity. Assessment in Education: Principles, Policy & Practice 29, 674–688. doi:10.1080/0969594X.2022.2147901.

Lesterhuis, M., 2018. The validity of comparative judgement for assessing text quality: An assessor's perspective. Ph.D. thesis. University of Antwerp.

Luce, R., 1959. On the possible psychophysical laws. The Psychologcal Review 66, 482–499. doi:10.1037/h0043178.

Marshall, N., Shaw, K., Hunter, J., Jones, I., 2020. Assessment by comparative judgement: An application to secondary statistics and english in new zealand. New Zealand Journal of Educational Studies 55, 49–71. doi:10.1007/s40841-020-00163-3.

Pollitt, A., 2012a. Comparative judgement for assessment. International Journal of Technology and Design Education 22, 157—170. doi:10.1007/s10798-011-9189-x.

Pollitt, A., 2012b. The method of adaptive comparative judgement. Assessment in Education: Principles, Policy and Practice 19, 281—300. doi:10.1080/0969594X.2012.665354.

Pollitt, A., Elliott, G., 2003. Finding a proper role for human judgement in the examination system. URL: https://www.cambridgeassessment.org.uk/Images/109707-monitoring-and-investigating-comparability-a-proper-role-for-human-judgement.pdf. research & Evaluation Division.

Thurstone, L., 1927. A law of comparative judgment. Psychological Review 34, 482–499. doi:10.1037/h0070288.

van Daal, T., Lesterhuis, M., Coertjens, L., Donche, V., De Maeyer, S., 2019a. Validity of comparative judgement to assess academic writing: examining implications of its holistic character and building on a shared consensus. Assessment in Education: Principles, Policy & Practice 26, 59–74. doi:10.1080/0969594X.2016.1253542.

van Daal, T., Lesterhuis, M., Coertjens, L., Donche, V., De Maeyer, S., 2019b. Validity of comparative judgement to assess academic writing: examining implications of its holistic character and building

on a shared consensus. Assessment in Education: Principles, Policy & Practice 26, 59–74. doi:10.1080/0969594X.2016.1253542.

Verhavert, S., Bouwer, R., Donche, V., De Maeyer, S., 2019. A meta-analysis on the reliability of comparative judgement. Assessment in Education: Principles, Policy and Practice 26, 541–562. doi:10.1080/0969594X.2019.1602027.

Whitehouse, C., 2012. Testing the validity of judgements about geography essays using the adaptive comparative judgement method. URL: https://filestore.aqa.org.uk/content/research/CERP_RP_CW_24102012_0.pdf?download=1. aQA Education.