Review of: "Analogical Visuospatial Matrix Reasoning, Verbal Relational Reasoning, Verbal IQ and Memory Relationships With Maths and Science: A Behavioural and fMRI Study"

Santo Di Nuovo[1]

1 University of Catania

Potential competing interests: No potential competing interests to declare.

The aim of the article by Gountas and Moraes (2024) is to combine behavioural and functional magnetic resonance imaging (fMRI) measures to discover relationships between the effects of analogical reasoning, visuospatial and verbal reasoning, working memory, and IQ and their report on students' performance in mathematics and science. This is definitely a good proposal.

The hypotheses are well articulated, and the results are very interesting, confirming – with neuropsychological support – a strong relationship between verbal analogical reasoning and performance in mathematics and science.

The theoretical background (including neuroscientific foundation) of the study and the educational consequences of the findings is well laid out in the document.

Some methodological concerns should be highlighted regarding data design and analysis.

As regards the tools, I wonder whether verbal working memory, assessed using the backward digit span memory test, is adequately represented by this measure, involving - unlike the forward digit span - also cognitive control and executive functions, i.e., frontal activities (Yang et al., 2015; Donolato et al., 2017). Furthermore, visuospatial processing could also be involved in backward verbal tasks (for example, Larrabee and Kane, 1986; in adults: Hoshi et al., 2000).

Another concern concerns the limited sample (34 adolescents), which makes the results of the Structural Equation Modeling less reliable, requiring the use of the Warp Partial Least Squares method. Wolf et al. (2013) claimed that in SEM sample size requirements “one size does not fit all,” but suggested also the risks of underestimating bias, systematic errors, and small effects when a small sample is used. Can the Warp PLS method avoid these risks?

In Gountas and Moraes’ study (2024), another issue interacts with the sample size necessary to ensure the reliability of the results, namely the differences between genders. In the sample, there are equal numbers of girls and boys, but no data are shown on the differences between these two samples, found in most of the literature on cognitive skills after puberty, particularly in verbal and visuospatial skills (e.g., Hill et al., 2014; Ibbotson and Roque-Gutierrez, 2023). If these differences in the sample are significant for some variables, the model analysis should take gender into account, maybe by splitting the confirmatory models.

In the Limitations paragraph, the Authors admit that “The small sample size (N=34) is considered adequate for using Warp PLS but larger samples are much better for testing more specific differences regarding age groups within the category 11-15 as well as possible gender differences between males and females". This is useful for further studies, but gender differences – if they actually exist in the sample – could introduce a confounding variable not considered in the present model.

Should the Authors verify, with a preliminary analysis of covariance in the behavioural measures, whether there are relevant gender differences in their sample?

The clarification of these points could resolve methodological doubts and add value to this interesting work.

REFERENCES

Donolato, E., Giofrè, D., Mammarella, I.C. (2017) Differences in Verbal and Visuospatial Forward and Backward Order Recall: A Review of the Literature. *Frontiers in Psychology, 8*:663. doi: 10.3389/fpsyg.2017.00663

Hill, A.C., Laird, A.R., Robinson, J.L. (2014). Gender differences in working memory networks: a BrainMap meta-analysis. *Biological Psychology,102*:18-29. doi: 10.1016/j.biopsycho.2014.06.008.

Hoshi, Y., Oda, I., Wada, Y., Ito, Y., Yamashita, Y., Oda, M., et al. (2000). Visuospatial imagery is a fruitful strategy for the digit span backward task: a study with near-infrared optical tomography. *Cognitive Brain Research 9*, 339–342. doi: 10.1016/S0926-6410(00)00006-9

Ibbotson, P., Roque-Gutierrez, E. (2023). The development of working memory: Sex differences in accuracy and reaction times. *Journal of Cognition and Development, 24*(4), 581–597. https://doi.org/10.1080/15248372.2023.2178437

Larrabee, G. J., Kane, R. L. (1986). Reversed digit repetition involves visual and verbal processes.*International Journal of Neuroscience, 30*, 11–15. doi: 10.3109/00207458608985649

Loprinzi, P.D., Frith E. (2018). The Role of Sex in Memory Function: Considerations and Recommendations in the Context of Exercise. *Journal of Clinical Medicine, 31*;7(6):132. doi: 10.3390/jcm7060132.

Wolf, E.J., Harrington, K.M., Clark, S.L., Miller, M.W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational Psychological Measurement, 76*(6):913-934. doi: 10.1177/0013164413495237.

Yang, Z., Jutagir, D. R., Koyama, M. S., Craddock, R. C., Yan, C. G., Shehzad, Z., et al. (2015). Intrinsic brain indices of verbal working memory capacity in children and adolescents. *Developmental Cognitive Neuroscience, 15*, 67–82. doi: 10.1016/j.dcn.2015.07.007