Habilidades Visuoespaciales para Aprender STEM con Multimedios

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Resumen

Habilidades Visuoespaciales

- Relación con STEM y STEAM
- Relación con género
- Meta-Análisis
- Reciente libro Springer

VAR: Batería de Tests Visuoespaciales

- Herramienta de administración
- Ejemplos de tests

Proyecto de Investigación

- Fondecyt 11180255
- Carga cognitiva y multimedios de química
- Habilidades visuoespaciales
- Género

Conclusiones e Implicancias

Habilidades Visuoespaciales y STEM (STEAM)

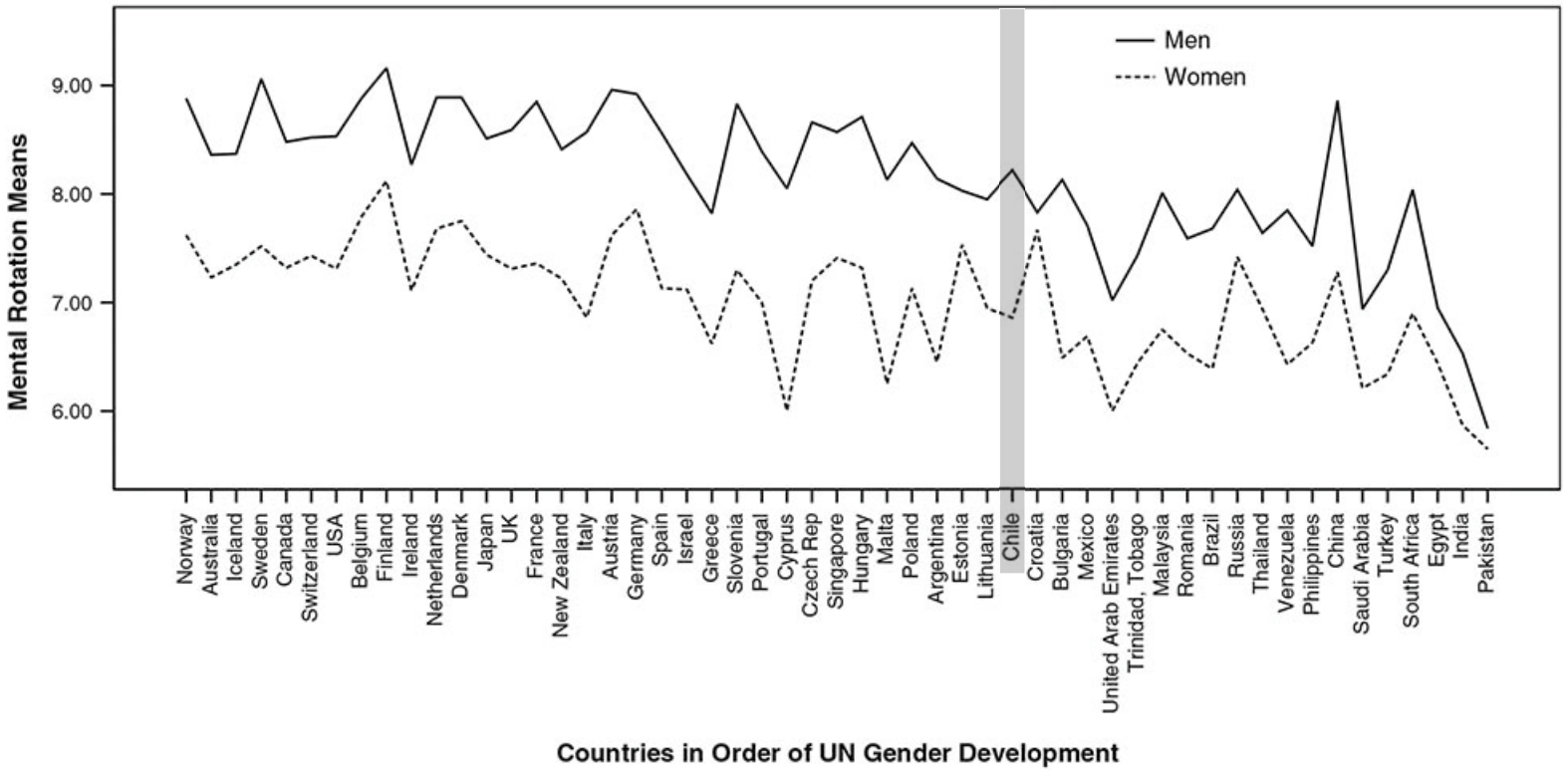
Aprender STEM y STEAM requiere de habilidades visuoespaciales [1,2]

Estudio de rotación mental (Canadá, *N* > 600 estudiantes)
STEM (biología, física, ingeniería) > no-STEM (ciencias sociales, humanidades) [3]

1. Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, *101*(4), 817-835. doi: 10.1037/a0016127
2. Castro-Alonso, J. C., & Uttal, D. H. (2019). Spatial ability for university biology education. In S. Nazir, A.-M. Teperi & A. Polak-Sopińska (Eds.), *Advances in human factors in training, education, and learning sciences: Proceedings of the AHFE 2018 International Conference on Human Factors in Training, Education, and Learning Sciences* (pp. 283-291). Cham, Switzerland: Springer. doi: 10.1007/978-3-319-93882-0_28
3. Peters, M., Laeng, B., Latham, K., Jackson, M., Zaiyouna, R., & Richardson, C. (1995). A redrawn Vandenberg and Kuse Mental Rotations Test: Different versions and factors that affect performance. *Brain and Cognition*, *28*(1), 39-58. doi: 10.1006/brcg.1995.1032

Habilidades Visuoespaciales y Género

53 países (*N* > 200.000)



Lippa, R. A., Collaer, M. L., & Peters, M. (2010). Sex differences in mental rotation and line angle judgments are positively associated with gender equality and economic development across 53 nations. *Archives of Sexual Behavior*, *39*(4), 990-997. doi: 10.1007/s10508-008-9460-8

Meta-Análisis

Educational Psychology Review (2019) 31:361–387
https://doi.org/10.1007/s10648-019-09469-1

META-ANALYSIS

Gender Imbalance in Instructional Dynamic Versus Static Visualizations: a Meta-analysis

Juan C. Castro-Alonso[1] · Mona Wong[2] · Olusola O. Adesope[3] · Paul Ayres[4] · Fred Paas[5,6]

Published online: 21 January 2019

Abstract
Studies comparing the instructional effectiveness of dynamic versus static visualizations have produced mixed results. In this work, we investigated whether gender imbalance in the participant samples of these studies may have contributed to the mixed results. We conducted a meta-analysis of randomized experiments in which groups of students learning through dynamic visualizations were compared to groups receiving static visualizations. Our sample focused on tasks that could be categorized as either biologically secondary tasks (science, technology, engineering, and mathematics: STEM) or biologically primary tasks (manipulative–procedural). The meta-analysis of 46 studies (82 effect sizes and 5474 participants) revealed an overall small-sized effect ($g+ = 0.23$) showing that dynamic visualizations were more effective than static visualizations. Regarding potential moderators, we observed that *gender* was influential: the dynamic visualizations were more effective on samples with less females and more males ($g+ = 0.36$). We also observed that *educational level*, *learning domain*, *media compared*, and *reporting reliability measures* moderated the results. We concluded that because many visualization studies have used samples with a gender imbalance, this may be a significant factor in explaining why instructional dynamic and static visualizations seem to vary in their effectiveness. Our findings also support considering the gender variable in research about cognitive load theory and instructional visualizations.

Keywords Dynamic and static visualization · Gender and spatial ability · STEM and manipulative–procedural tasks · Cognitive load theory · Meta-analysis

Castro-Alonso, J. C., Wong, M., Adesope, O. O., Ayres, P., & Paas, F. (2019). Gender imbalance in instructional dynamic versus static visualizations: A meta-analysis. *Educational Psychology Review*, *31*(2), 361-387. doi: 10.1007/s10648-019-09469-1

Difusión del Meta-Análisis

Education and training | Dr Juan Cristóbal Castro-Alonso

Gender and visuospatial processing in multimedia STEM learning

Multimedia learning research comparing effectiveness of static and dynamic visualizations in STEM disciplines has revealed mixed results, because it has ignored gender distribution among its participants. Although research is suggestive for gender differences in visuospatial processing, the failure to report gender compositions in many studies makes it impossible to draw conclusions on the moderating effects of these differences on learning. Dr Juan Cristóbal Castro-Alonso, an educational psychology researcher with focus on multimedia at Universidad de Chile, has led a meta-analysis to establish whether gender imbalance exists in research on learning through visualizations and how it might be affecting study outcomes.

As multimedia and video are getting cheaper to produce, they are becoming more popular as tools for classroom instruction. With increasing access to digital technologies around the world, teachers, commissioners and policy makers are being encouraged to use more static and dynamic visuals in their lessons even though there is no unequivocal evidence to support this approach. Dr Juan Cristóbal Castro-Alonso is an educational psychology researcher at Universidad de Chile focused on better understanding whether the use of multimedia makes learning science more efficient and—if so—under what circumstances.

COGNITIVE RESOURCES ARE LIMITED

Dr Castro-Alonso and his collaborators in Australia and the Netherlands have previously noted that different types of instructional materials might be better at supporting the learning of different types of tasks. They have argued that these differences are related to the functioning of specific neural systems that underpin the acquisition of particular skills, and are also mediated by the amount of mental resources required to process the specific multimedia materials.

For example, with dynamic materials like videos or animations, the learner must often process more information due to the transient nature of dynamic presentations. Despite this concern, dynamic materials appear to be better at supporting manipulative tasks, i.e. tasks that require physical action (like replicating an origami model). In contrast, static images seem more effective at supporting learning for non-manipulative tasks, i.e. tasks that are more cognitive than physical (like solving abstract symbol problems).

This difference can be explained by cognitive load theory, which proposes that a learner has a limited amount of cognitive resources (working memory) and any loss of this capacity to tasks that do not directly support learning or require more processing is detrimental to the overall learning effectiveness. If more cognitive resources are spent on processing teaching materials, there is often not enough left over to efficiently complete the task at hand.

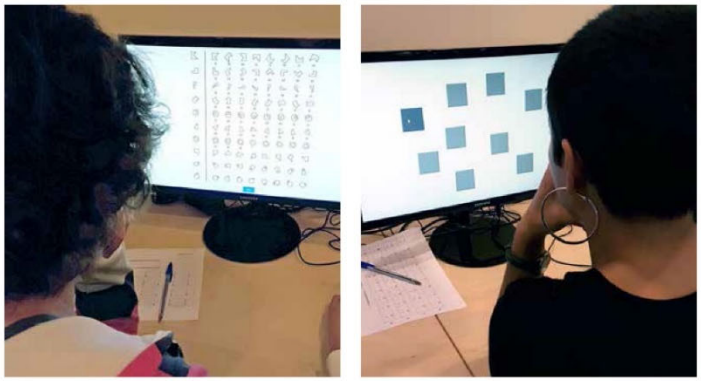
MIRROR NEURONS TO THE RESCUE

Within an evolutionary approach to cognitive load theory, it has been suggested that dynamic images might be able to well-support learning tasks that require movement because manipulative tasks evolved as a primary skill in humans and are therefore likely processed by a separate system (for example, mirror neurons). This specialized circuit allows learning of manipulative skills from transient images without exerting extra effort. In contrast, learning a non-manipulative skill from a moving image requires effort to remember the information before attempting the task. As such, by the time the student attempts the task, processing learning materials has already diminished their cognitive resources. In this case, the use of dynamic multimedia may hinder rather than support student performance.

BUT NOT SO FAST

A plausible theoretical framework notwithstanding, Dr Castro-Alonso points out that the data on learning from visuals is complex and difficult to interpret with any degree of certainty. First, it remains unclear whether differences between learning efficacy from static versus dynamic images in fact exist. Studies that report these differences often neglect to control for many potentially moderating variables that relate to the materials themselves. Some of these factors are appeal, media, realism, size, and interaction. Second, participant-related variables—including gender, spatial abilities or attained level of education—remain unexplored. In a recently published meta-analysis, Dr Castro-Alonso and colleagues aimed to examine whether differences in learning efficacy between static vs dynamic visuals indeed exist when studies are pooled together; they also looked to identify the factors that affect any existing differences.

A meta-analysis is a type of study that compiles all studies that aim to answer a specific question. Studies are selected on pre-specified inclusion and exclusion criteria, and then combined to identify a common effect. Dr Castro-Alonso and colleagues searched for and included studies that reported results of randomized experiments where two groups of students were compared: a group learning from static images and a group leaning from dynamic visualizations. Studies were included if they reported measurable outcomes that could be used in statistical analysis and where they included tasks that could

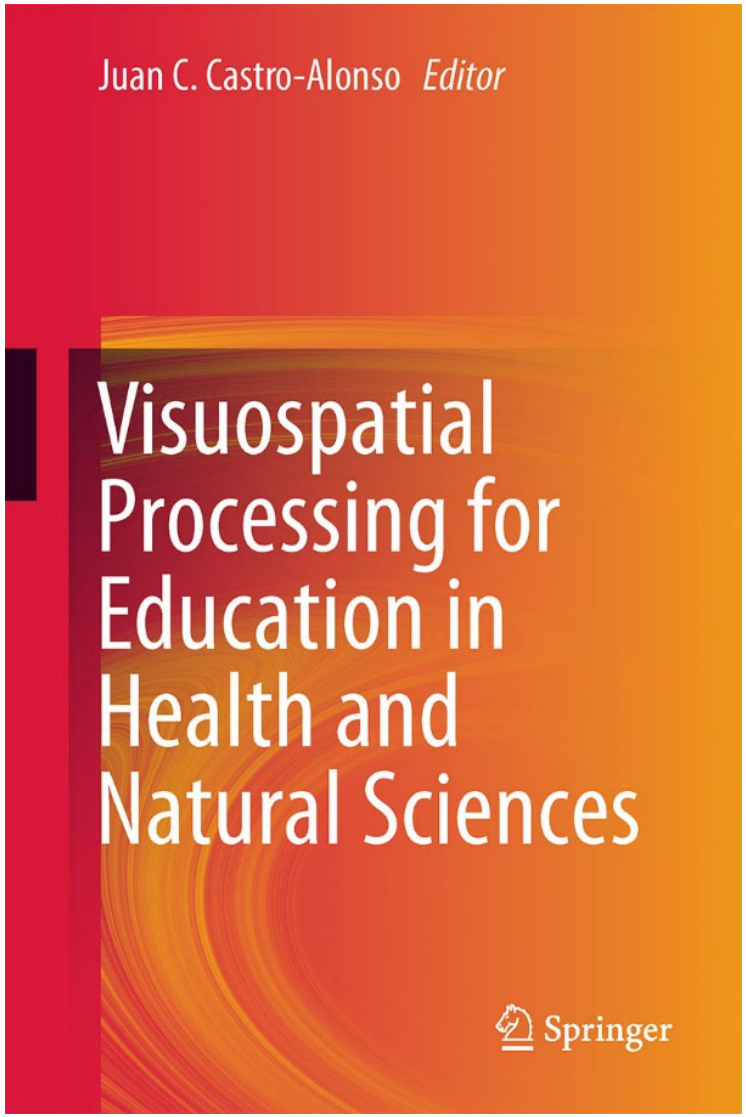


Female university participants attempting computer-based visuospatial processing tasks.

As access to digital technologies increases, teachers are encouraged to use static and dynamic visuals in classrooms – what's the evidence?

https://researchoutreach.org/articles/gender-visuospatial-processing-multimedia-stem-learning/

Reciente libro

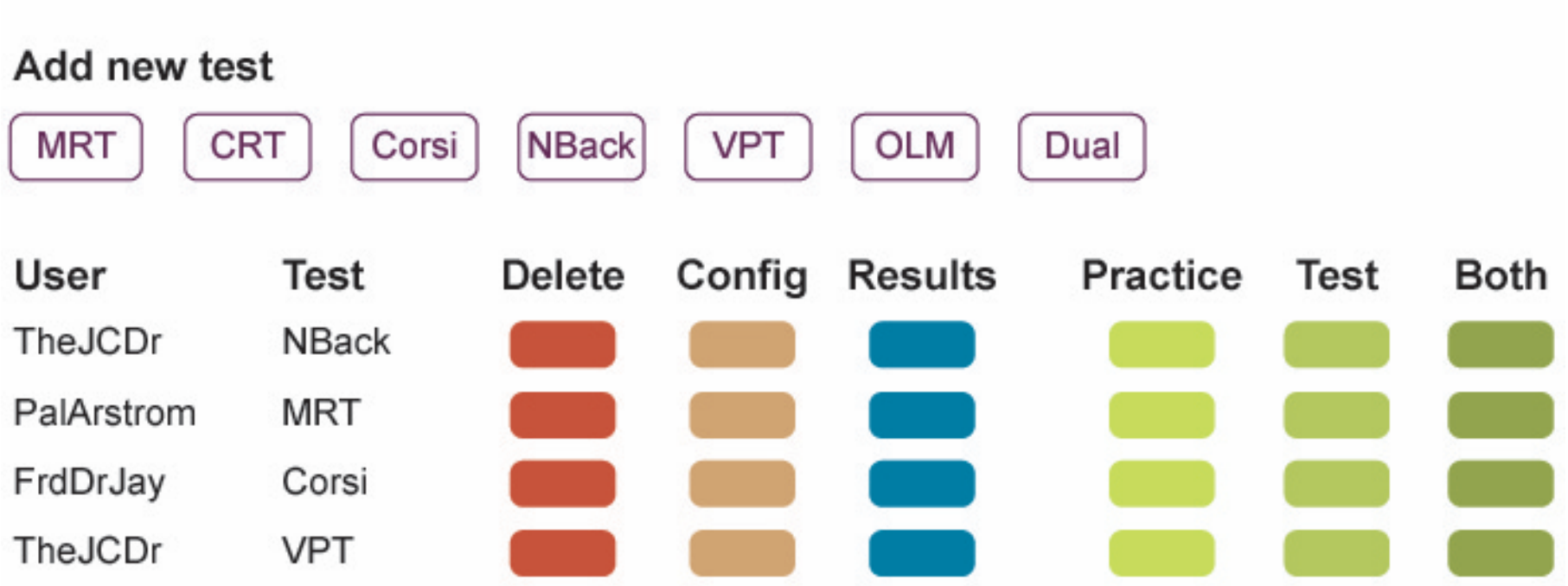


Castro-Alonso, J. C. (Ed.). (2019). *Visuospatial processing for education in health and natural sciences*. Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20969-8

Castro-Alonso, J. C. (Ed.). (2019). *Visuospatial processing for education in health and natural sciences*. Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20969-8

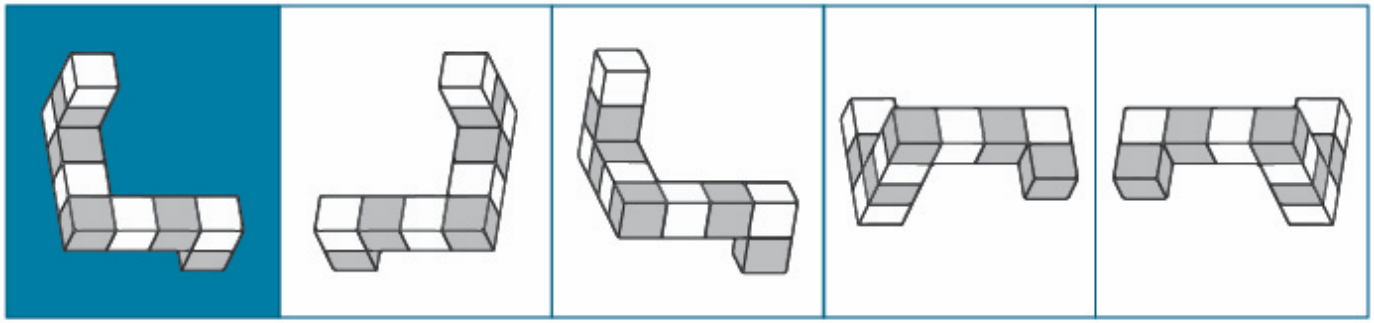
VAR: Batería de Tests Visuoespaciales

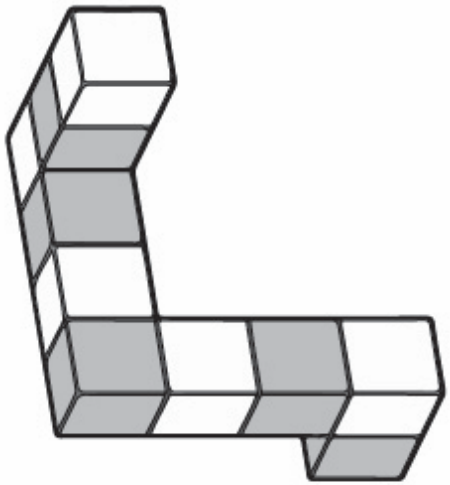
Herramienta de Administración



Castro-Alonso, J. C., Ayres, P., & Paas, F. (2019). VAR: A battery of computer-based instruments to measure visuospatial processing. In J. C. Castro-Alonso (Ed.), *Visuospatial processing for education in health and natural sciences* (pp. 207-229). Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20969-8_8

Mental Rotations Test





X axis rotation - 30° +

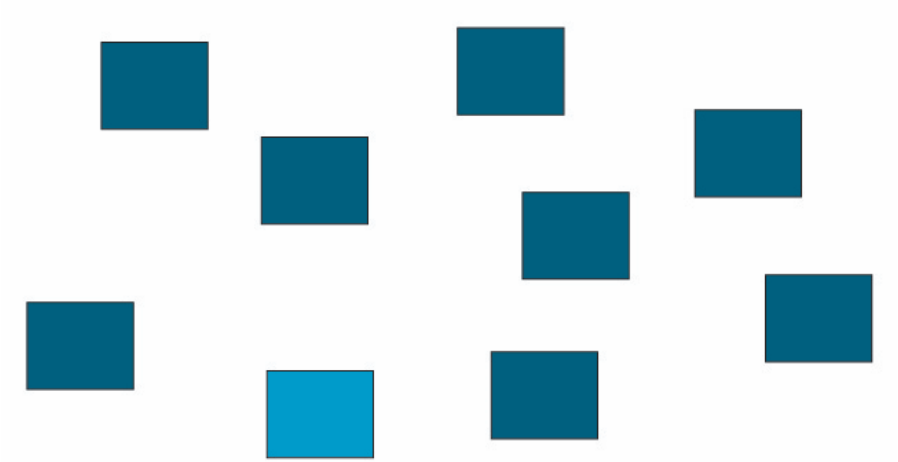
Y axis rotation - 0° +

Z axis rotation - 0° +

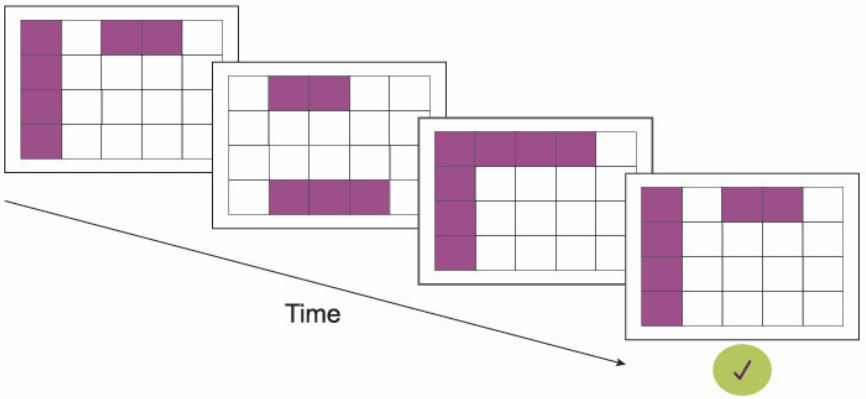
Castro-Alonso, J. C., Ayres, P., & Paas, F. (2019). VAR: A battery of computer-based instruments to measure visuospatial processing. In J. C. Castro-Alonso (Ed.), *Visuospatial processing for education in health and natural sciences* (pp. 207-229). Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20969-8_8

Tests de Memoria de Trabajo Espacial

Corsi Block Tapping Test



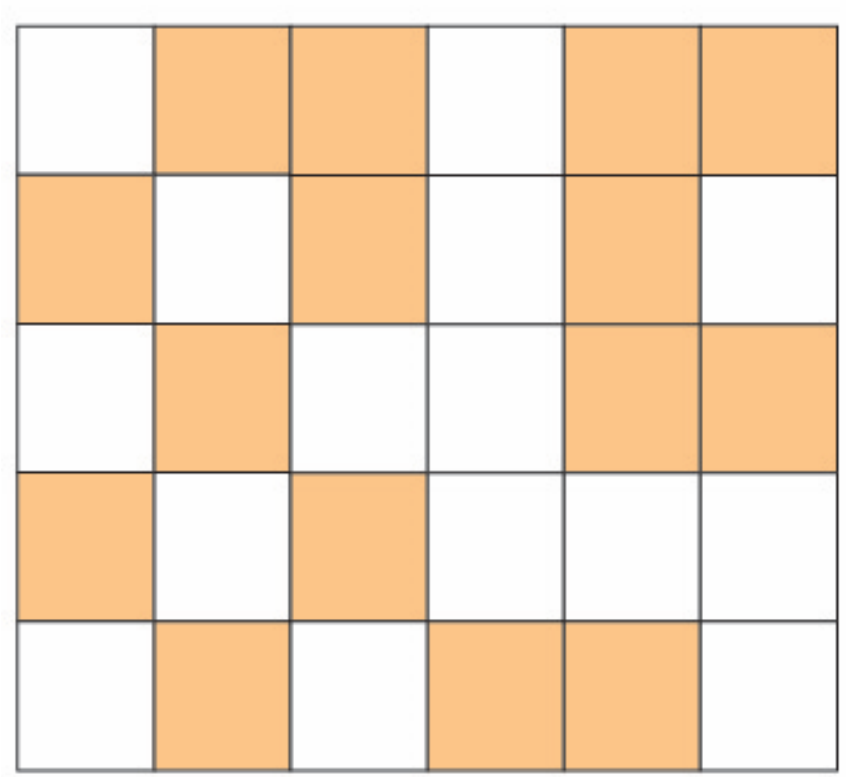
Spatial N-Back Task



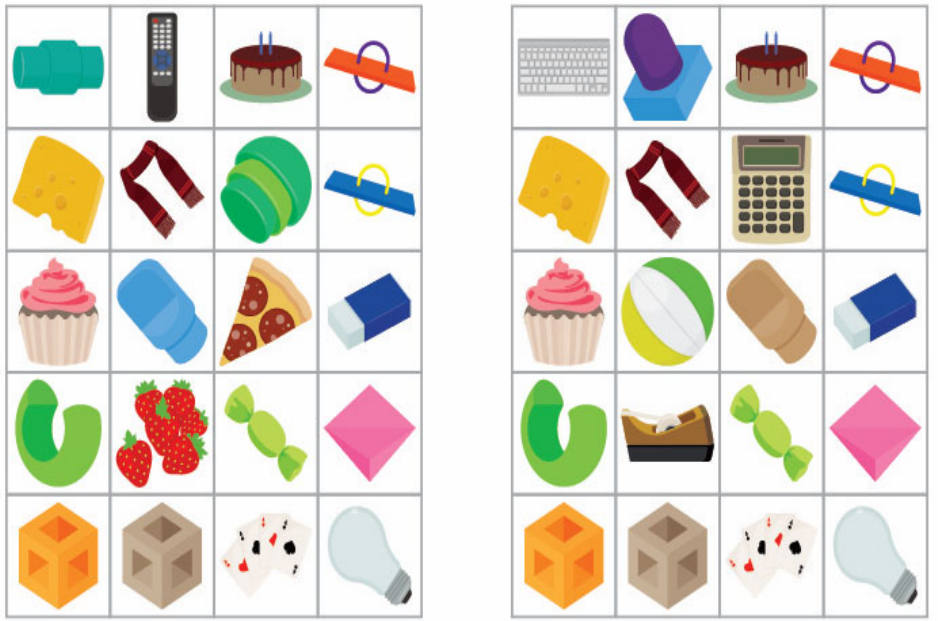
Castro-Alonso, J. C., Ayres, P., & Paas, F. (2019). VAR: A battery of computer-based instruments to measure visuospatial processing. In J. C. Castro-Alonso (Ed.), *Visuospatial processing for education in health and natural sciences* (pp. 207-229). Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20969-8_8

Tests de Memoria de Trabajo Visual

Visual Patterns Test



Object Identity Memory Test



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Proyecto Fondecyt 11180255

Objetivos Específicos

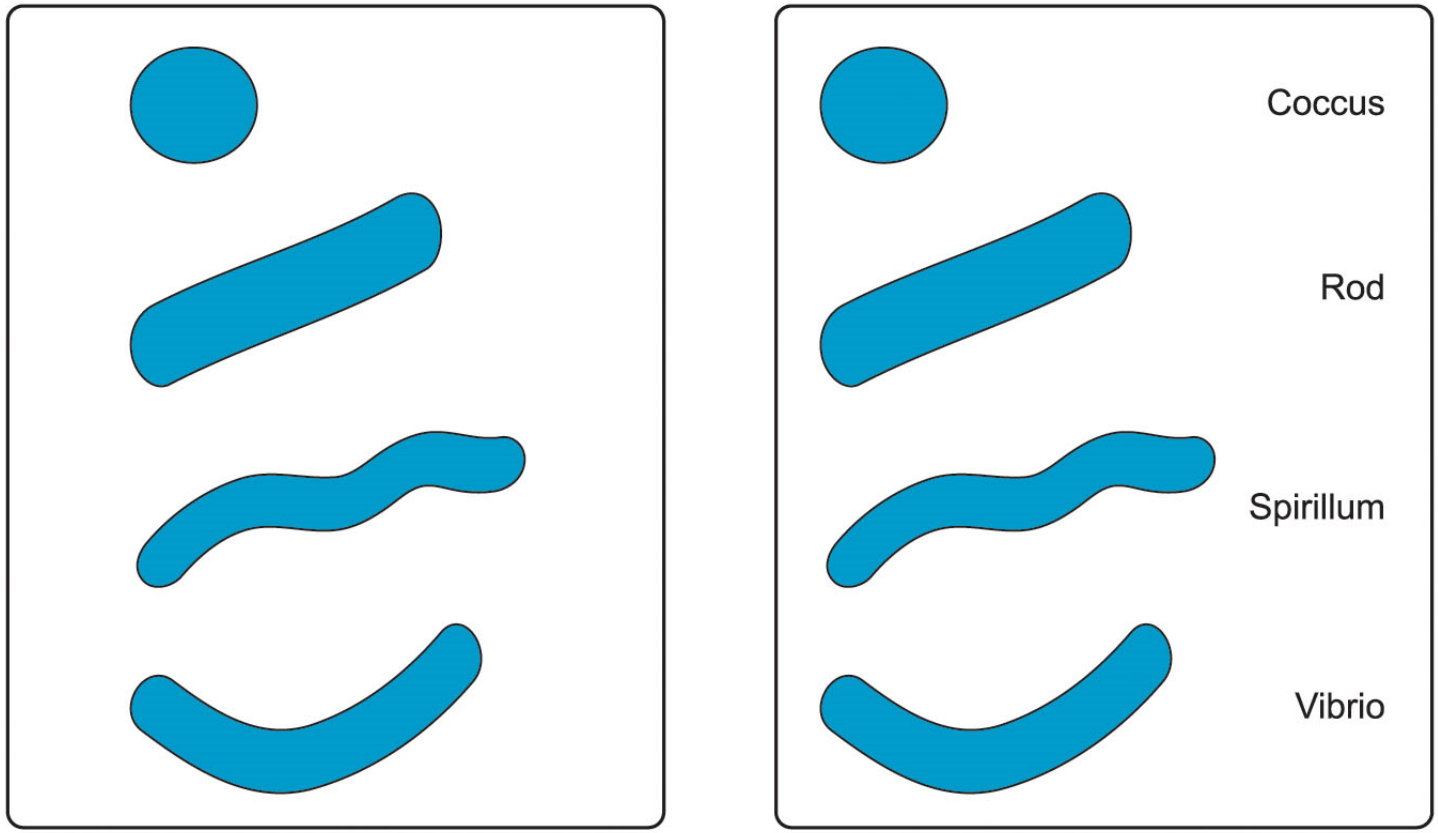
1. Investigar relaciones entre aprendizaje de química orgánica en multimedios y diferentes habilidades visuoespaciales

2. Comparar aprendizaje de química orgánica en multimedios, entre mujeres y hombres

3. Comparar aprendizaje de química orgánica en multimedios con textos auditivos (narración) versus textos visuales (escrito)

Castro-Alonso, J. C., Ayres, P., Wong, M., & Paas, F. (2019). Visuospatial tests and multimedia learning: The importance of employing relevant instruments. In S. Tindall-Ford, S. Agostinho & J. Sweller (Eds.), *Advances in cognitive load theory: Rethinking teaching* (pp. 89-99). New York, NY: Routledge. doi: 10.4324/9780429283895-8

Carga Cognitiva: *The Modality Effect*



" Coccus is round; rod is cylindrical . . . "

Castro-Alonso, J. C., & Sweller, J. (2020). The modality effect of cognitive load theory. In W. Karwowski, T. Ahram & S. Nazir (Eds.), *Advances in human factors in training, education, and learning sciences: Proceedings of the AHFE 2019 International Conference on Human Factors in Training, Education, and Learning Sciences* (pp. 75-84). Cham, Switzerland: Springer. doi: 10.1007/978-3-030-20135-7_7

Conclusiones e Implicancias

Las habilidades visuoespaciales son importantes en STEM y STEAM

- En mayor o menor medida, dependiendo de la habilidad y tarea

Las habilidades visuoespaciales son afectadas por el género

- En mayor o menor medida, en distintas direcciones, dependiendo de la habilidad

El aprendizaje en multimedios es afectado por el género

VAR, una batería de tests visuoespaciales

- Incluye diferentes tests adaptables y herramienta de administración

Proyecto de Investigación

- Fondecyt 11180255
- Habilidades visuoespaciales, género, carga cognitiva y multimedios de química