Área: EDU

Can I picture what you see? Visualizing mental representations of molecules

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Palavras Chave: cognition, visualization, visual representations, eye-tracking, mental rotation.

Highlights

Images of the likely mental representation of molecular models were generated from a novel method combining 3D mapping of quantitative measurements of physical rotation and gaze fixation.

Abstract

INTRODUCTION: The mental processes involved in the perception, manipulation, and understanding of molecular models are an ongoing topic of research in chemistry education. One challenge is to examine the mental models related to the interpretation of external models[1]. In this work we use eye-tracking measures to obtain an image that we believe approximates the internal representations of molecular models. We rely on the fact that eye movement is controlled by internal cognitive processes that integrate the sensorimotor system, the nature of the objects observed, and the context in which the observation takes place [2,3]. Therefore, visual attention data of an external molecular model may provide a good measure of its internal counterpart. **METHODS:** We recorded physical rotation and gaze fixation (GF) during a task involving two representations of the same 3D molecular model: a static one, as **r**eference, *Rs*, (Fig A) e an interactive one, the **w**orking model, *Wi*. The task was rotating *Wi* so it got as close as possible to *Rs*. An ordinary laptop equipped with a mouse and eye-tracking device was used. A novel method developed by our group was used to map GF data over the 3D model and generate images of the likely internalized models (Figs B1 and B2, colored in transparency scale).

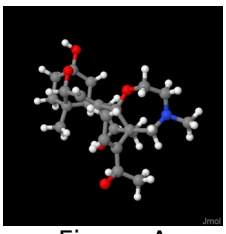

Figure A

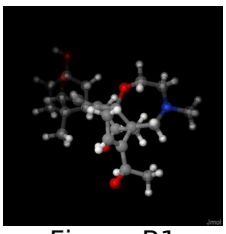

Figure B1

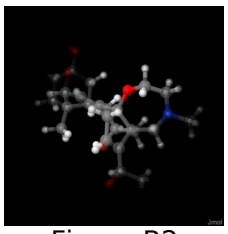

Figure B2

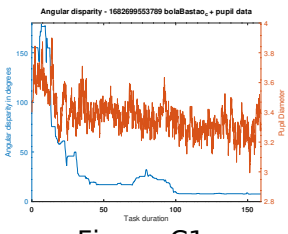

Figure C1

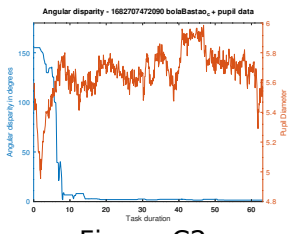

Figure C2

RESULTS AND DISCUSSION: Data from the task solving process for two individuals (1 and 2) are shown in Figures B1, B2, C1, and C2. The images of the cumulative GF for *Wi* (Figs. B1 and B2) indicate that each person internalizes distinct regions of the same external model. Relevant differences are also observed in the interaction with the model (blue line - rotational difference between *Rs* and *Wi* over time) and pupil dilation (red line - related to cognitive effort), shown in Fig. C1 and C2. The process analysis (click and see an animation of the task solving process in the supplemental material) suggests that solving the task with interactive models apparently requires recursively repeating steps similar to those involved in tasks with static images[3]: searching and comparing regions in *Rs* and *Wi*, followed by interacting with *Wi* for adjustment. However, this is still to be tested in broader studies. **CONCLUSION:** the present method is a promising addition to the repertoire for studying the role of molecular models in chemical education. We consider combining qualitative research methods focusing on interpreting chemical information from virtual and physical molecular models.

REFERENCES: 1: Harle & Towns, *J. Chem. Ed.*, 2011, 88(3) 351; Stieff et al. *J. Ed. Psychol.*, 2018, 110(8), 1160; 2:, Kümmerer M.& Bethge M., *Ann. Rev. Vis Sci* 2023, 9(1), 269; 3: Xue et al., *Sci. Reports* 2018,7, 10076.

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