Extracting pertinent and useful spatial information from an animation of a 3D anatomical structure: an eye-tracking pilot study

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ABSTRACT :

Functional anatomy is a spatially complex instructional domain that requires learners to mentally manipulate the anatomical structure to imagine its spatial orientation. Involving spatial reasoning and mental imagery, these mental transformations are challenged by the need to take into account the 3D body space. The experimental pilot study reported here was conducted to explore the role of visuo-spatial ability when processing an animation with a 3D rotating model (3D animation) as well as performing spatial task. Eye-tracking data were collected with 10 psychology students. Associations were found between time spent in AOIs of the scapula and mental rotation ability. Albeit less pronounced, a similar trend was found for the perspective-taking ability. Preliminary analysis of the verbal reporting during the learning phase revealed trends in two distinct strategies.

133 mots

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Functional anatomy is a spatially complex domain requiring learners to correctly (re)locate an anatomical structure within the three-dimensional body space. Learners may apply either an mental rotation transformation on the structure-object or a spatial egocentric perspective-taking transformation, in which a new perspective is adopted away from the observation point. Spatial abilities in these strategies are influenced by several factors, such as the stimuli. Body-based stimuli (real or avatar) are particular as they might equally promote either of the two transformation strategies (Zacks & Tversky, 2005). Additionally, when performing mental transformation strategies participants may use strategies different from those reasonably expected. Therefore, learning anatomy raises interesting issues regarding the role of these two spatial abilities as well as the choice of the appropriate mental strategy.

3D animations provide additional spatial information about the 3D model. The role of visuo-spatial abilities and their relation to animation processing are currently analyzed in two hypotheses (Hegarty & Sims, 1994; Mayer & Sims, 1994). The compensating hypothesis claims that animation can compensate learners' low-spatial abilities by providing explicit external representation. The ability-as-enhancer hypothesis states that high-spatial learners are cognitively better equipped to process animations. In two experiments (Berney, 2014), participants had to study an anatomical structure from 3D animations. Regarding mental rotation, findings of the first experiment were consistent with the compensating hypothesis, while the findings of the second experiment favored the ability-as-enhancer hypothesis. As far as the perspective-taking ability is concerned, it supported the compensating hypothesis. According to the literature, the two hypotheses qualifying the spatial abilities are related to learners processing of animations. From these initial mental representations, participants usually perform subsequent mental transformations to achieve (post)tasks. A clear distinction between the spatial abilities involved in animation processing and in performing (post)tasks would provide a better insight into animation and spatial ability interplay. This pilot study examined these issues and used eye-movement tracking to observe participants' processing during the initial learning phase and the subsequent spatial task phase. We hypothesized that participants using a spatial perspective-taking strategy would elaborate a more global mental representation by trying to align the position of the scapula on the avatar's body. However, participants using a mental rotation strategy would more likely focus on the scapula's landmarks and stare more briefly at the avatar.

Method

Ten psychology students (*M*age = 28, 4 females) at the Universities of Genève and Bourgogne voluntarily participated in the study.

The instructional material consisted of a 3D animation, a spatial anatomy post-test, and two visuo-spatial ability tests. The 3D animation consisted of a 3D scapula fully rotating (360°) on different anatomical planes with a human-like avatar acting as a permanent spatial anatomical reference.

Participants first studied a 3D animation of the anatomical space presenting a 3D pelvis within two spatial orientation reference systems (internal axes and external avatar). The two-part learning phase consisted of i) the 3D scapula animation (Figure 1a), and ii) a 6-trial training session. After studying the 3D animation, participants decided whether the anatomical positioning of the two images was congruent (Figure 1b). Hereafter, they looked for the frame depicting one of the two images in the 3D animation and evaluate the accuracy of their choice. Participants then completed the 32-item spatial post-test (Figure 1a) identical to the training session, without the double-checking part. Mental rotation (MRT) and perspective-taking (PTSO) abilities were assessed. Verbal data via cued retrospective reporting were collected. The experiment was presented on a Tobii T120 eye-tracker. Two AOIs were identified on each material: the scapula and the avatar. Number of fixation and fixation duration were analyzed from raw data. Long fixation duration on precise target(s) implies a deeper processing and more time dedication to either interpreting an area or connecting two components (Groff, 2013).

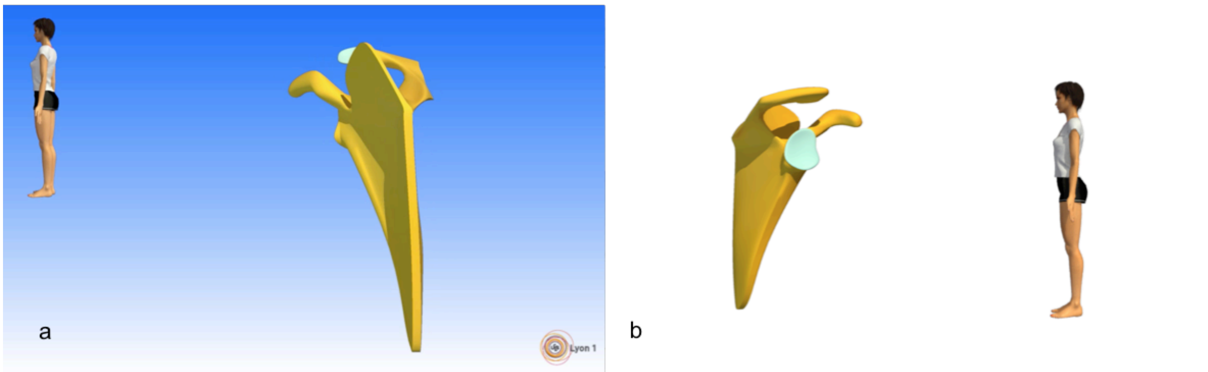

Figure 1 a) 3D scapula animation showing the scapula medial orientation, b) item of spatial test, showing non-congruent anatomical positioning.

First results and discussion

Relations between AOIs and visuo-spatial ability measures for the scapula 3D animation and the post-test were explored. Due to the small study sample, only correlation analyses indicating trends were provided. For the animation phase, correlations were found between PTSO and the scapula fixation duration ($r(8) = .50$, $p = .03$); the avatar fixation duration and PTSO scores ($r = -.9$, $p = .01$), as well as MRT scores ($r(8) = -.8$, $p = .05$). In the post-test phase, the scores of the MRT, respectively the PTSO, were significantly correlated with the scapula fixation duration ($r_{MRT}(8) = .7$, $p = .006$; $r_{PTSO}(8) = .8$, $p = .04$) and the number of scapula fixation ($r_{MRT}(8) = .65$, $p = .01$; $r_{PTSO}(8) =.82$, $p = .008$). High mental rotation ability (MRT) learners focused longer on the scapula than on the avatar during animation processing and during the post-test. This suggests that mental rotation ability is involved both in the initial animation processing and in subsequent mental transformations. The results from PTSO analyses are less clear. A preliminary analysis of the verbal reporting revealed trends in two distinct strategies. One compared the avatar's shoulders and the scapula's shade, the other focused mainly on the scapula's landmarks, such as the "blue-grey circle". The main limitation of this pilot study is the small study sample; future studies are needed to confirm the results. A full-scale experiment comparing external versus internal orientation references is being planned and results will be available for the EARLI conference.

Berney, S. (2014). *Learning complex information and 3D objects with animations : Effect of learners ' visuo-spatial abilities and design factors* (Doctoral dissertation). Université de Genève.

Groff, J. (2013). *Traitement cognitif des animations graphiques adaptées à la signalétique transport* (Doctoral dissertation). Université de Bourgogne, France.

Hegarty, M., & Sims, V. K. (1994). Individual differences in mental animation during mechanical reasoning. *Memory & Cognition*, *22*(4), 411–30.

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words ? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, *86*(3), 389–401.

Zacks, J. M., & Tversky, B. (2005). Multiple Systems for Spatial Imagery: Transformations of Objects and Bodies. *Spatial Cognition & Computation*, *5*(4), 271–306.

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