# Using microscope image-based computer generated 3D animations in teaching physiology

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**Introduction**: Conventional methods of teaching physiology may not stimulate students experienced in high performance 3D graphics and virtual worlds. Should we make more use of Computer Generated Images (CGI) in teaching difficult (threshold) concepts? Existing animations of physiological processes are mostly artist's impressions. Using sophisticated microscopes, 3D models of tissue and cellular structure can be built which are accurate to within 0.3µm. These can be used as 'scenes' for 3D-animations, thus generating a potentially powerful teaching aid. The challenge is to make better use of our huge archive of 3D image (research) data and incorporate it, as 3D animations, within our teaching. However, for 3D-animations to facilitate learning, care must be taken in their construction and design, to focus on the intended learning outcomes, and to avoid generating or reinforcing misconceptions. In this study we have considered multi-level learning (Johnstone 1991) and cognitive load (Pass et al. 2003) as crucial components in the animation design process. In this first stage, we have assessed the 3D spatial ability of a group of Life Science (University of Glasgow, GU) and Medical Visualisation (Digital Design Studio, DDS) students and aim to use the results to guide the cognitive loading of complex 3D animations . Here we present the progress of the 1st two stages of the project; animation design and cognitive testing.

**Methods** *(Animation Development)*: The first animation, related to hypertension, concentrates on the structure of the vascular wall and the functional link between the endothelial and smooth muscle cells via myo-endothelial junctions. Mouse mesenteric resistance arteries (0.3mm diameter) were stained and imaged using a confocal laser scanning microscope. 3D reconstructions were rendered in AMIRA software to enable key structures to be 'segmented'. Segmented objects were then transferred to MAYA animation software.

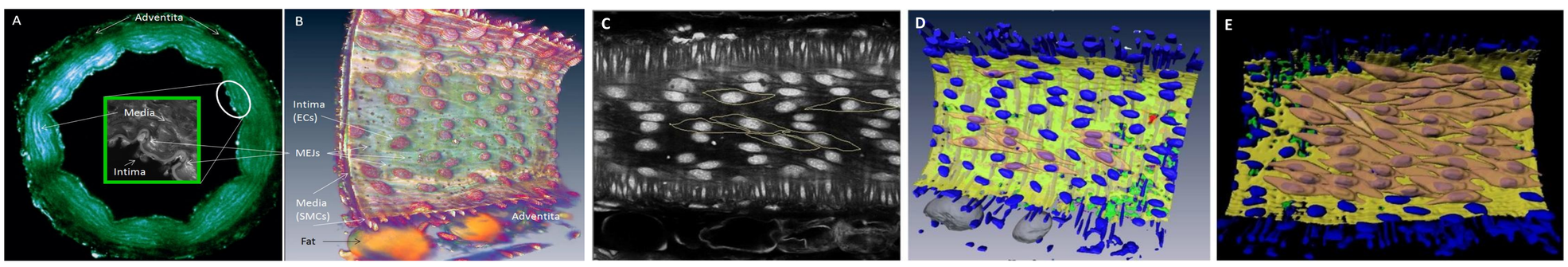


*Figure 1. Vascular structure; from microscope to MAYA. A) Standard histological cross section of a blood vessel. B) 3D reconstruction of a confocal laser scan of the vascular wall using AMIRA. C) Individual endothelial cells are outlined for segmentation. D) Construction of objects as wireframes with surfaces. E) Objects (surfaces) are imported to MAYA and duplicated prior to addition of animation layers.*

**Methods** *(Cognitive Testing)*: We tested the 3D spatial ability of two groups of students. One group were volunteers drawn from 2nd-4th year undergraduate single honours human biology students (n=22, M11, F11) . The second group were 'Masters in Medical Visualisation and Human Anatomy' students, which is run jointly between GU and DDS (n=17, M5, F12). Students were assessed using the Purdue Spatial Visualisation Test with Rotation (PSVT:R, Maede & Yoon 2013, Fig 2A). Students were presented with 30 different problems over a 15 minute period. Results of the PSVT:R were analysed for correlations between grade point average (GPA) and gender. DDS student scores were also correlated with specific 3D/Visualisation assignments.

**Results**: Life science students scored better in the PSVT:R test than DDS students (20.8±0.9 vs 16.9±0.8, $p<0.01$, unpaired t-test, figure 2B). There was no gender difference when comparing the whole group or within groups. No correlation was found between PSVT:R score and GPA (figure 2C-D).

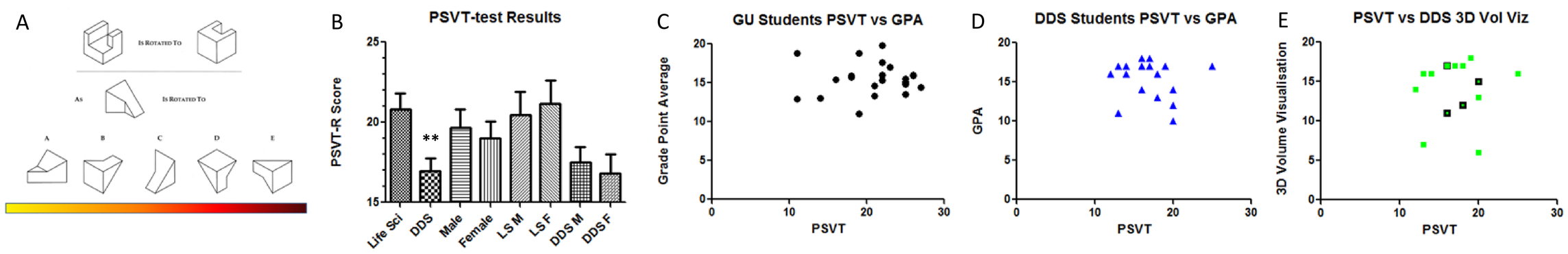


*Figure 2. 3D spatial ability test. A) Example of PSVT:R . B) Overall test results. C) GU students PSVT score vs GPA D) DDS students PSVT score vs GPA. E) DDS PSVT score vs results from a 3D Volumetric Visualisation assignment*

The 3D data set shown in figure 1E was used to create a 3 minute animation describing the importance of endothelial-derived nitric oxide in modulating vascular tone (figure 3).

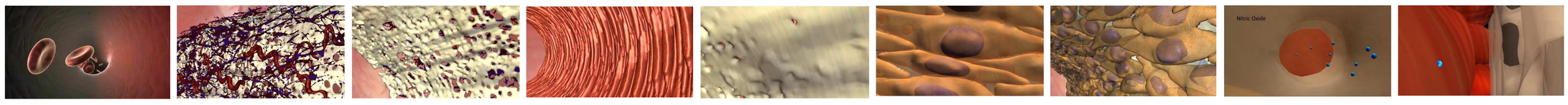


*Figure 3. Screen shots from the final animation to be shown to students along with a multiple choice quiz to assess understanding. The full movie can beviewed online at: www.cardiovascular.org (news page).*

**Discussion**: Complex interactive animations only facilitate learning when the scene is accurate (Falvo 2008). Furthermore, if cognitive load is too high then learning will not occur (Pass et al., 2003). We have described a data flow to enable the design of complex 3D animations which are anatomically accurate. We have also identified a 3D cognition test which can be used to measure spatial ability. Contrary to published reports, we find no difference in spatial ability between male and female students. GPA is not a predictor of spatial ability. Our hypothesis is that students with a high PSVT:R score will demonstrate greater comprehension of animations with a high cognitive load. Testing this hypothesis, using animations with varying cognitive loads (i.e. movement, text, commentary, interaction), constitutes the next (final) part of the project.

**References.**
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Maede Y & Yoon YS (2013). Educ Psychol Rev, 25;69-94.
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