Royal Society of Biology

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Case Study

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This case study describes the development of a novel kinaesthetic method for understanding and teaching the complex biomechanics of eye movements.

Background

Traditional text book methods for teaching eye movements – and the actions of the so-called 'extraocular' muscles that produce them – are confusing and difficult to understand for many students (Miller, 2007; Zang and He, 2010; Glittenberg and Binder, 2006; Bernd and Jakway, 2008).

This is because the student needs to (a) understand the various attachment points and lines of action of the six extraocular muscles (Fig. 1); and (b) visualise the three-dimensional rotations of the eyeball that occur in the 'x', 'y' and 'z' axes when each muscle contracts (Fig. 2).

Students struggling to understand this complex but important topic also discover that text books often give confusing and apparently contradictory accounts (Ahmen and Ali, 2002).

Fig. 1: The muscles that move the eyeball. Each eye is surrounded by six 'extraocular' muscles which are controlled by three separate nerves (on each side). The muscles have different points of attachment and lines of pull, producing so-called primary, secondary and tertiary actions when they contract. This can be challenging to understand, visualise and remember – particularly as the line of pull and action of each muscle changes as the eyeball rotates.

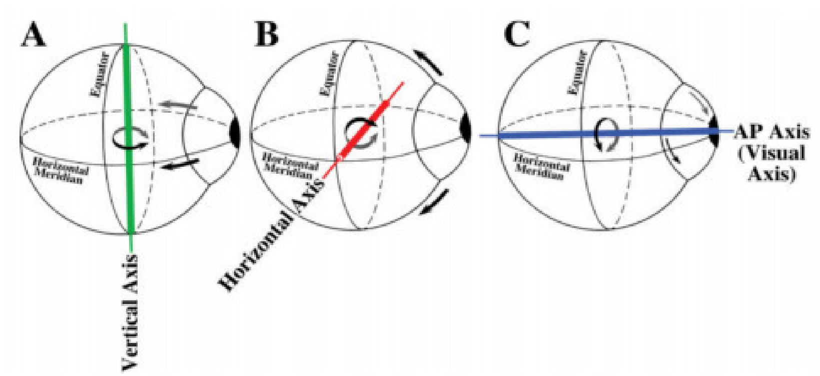

Fig. 2: Axes of rotation of the eye. Three-dimensional rotations of the eyeball occur in three orthogonal planes, which can be challenging for students to understand and visualise. Adapted from Bernd and Jakway (2008).

Reasons for introducing the method

The difficulty in learning and teaching eye movements is well-recognised. As such, many attempts have been made to address the problem, usually by constructing cumbersome working models of the eyeball using strings and pulleys – or by using computer simulations (Cogan, 1948; Williams, 1965; Iwanga et al., 2017; Maini et al., 2015; Bernd and Jakway, 2008; Allen et. al, 2014).

Models simulating eye movements are not generally/commercially available and, where they do exist within individual anatomy departments, are typically rather crude 'home-made' constructions. This makes this approach of limited practical use in most universities. Computer simulations are widely used in medical education and can be useful to visualise eye movements, but the experience is passive and does not allow students to gain an intuitive 'feel' for the 3D rotations of the globe.

In view of this, I wanted to devise a novel kinaesthetic method for teaching eye movements that did not require computer simulation or the construction of cumbersome mechanical models. This new method, which uses only the hands, is known colloquially at St George's as "finger guns".

The 'finger guns' technique

Medical and biomedical science students at St George's are taught to use their hands to simulate three dimensional rotations of the eyeball caused by particular muscles. From the position shown in Fig. 3, the index finger is used to represent the visual axis (line of sight) whilst the tip of the thumb represents the attachment point of the particular muscle being simulated.

Referring to diagrams and models of the eye, the student is able to use the method to literally 'feel' the rotation of the eye, in slow motion, as the thumb is moved (rather like a joystick) along the line of action of the muscle. The resulting position of the index finger indicates the changing line of sight.

The method is easy to teach, requires no cumbersome models or computer simulations, works for all six extraocular muscles, and copes easily with any initial position of gaze. It also resolves the (apparent) discrepancy between differing accounts identified in different undergraduate texts.

A key benefit of the finger guns technique is that it is an *active* (kinaesthetic) method that encourages student engagement, avoids passive learning and promotes comprehension over rote memorisation, which is a common and recurring thread in all of my teaching sessions.

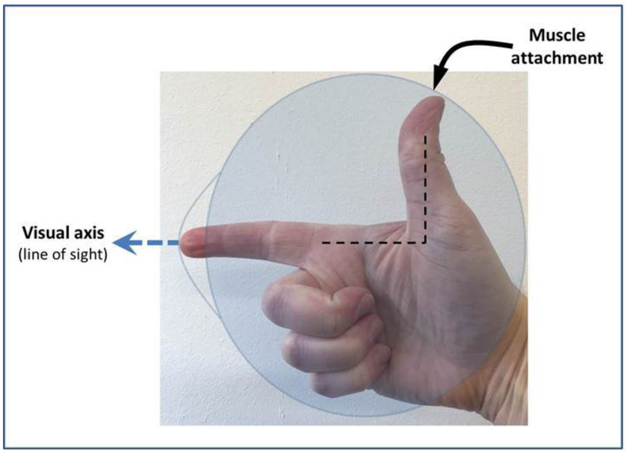

Fig. 3: The 'finger guns' method. The student holds the hand as shown [left] to model the rotation of the eyeball. The index finger represents the visual axis (line of sight) whilst the thumb represents the attachment point of the muscle being modelled. As the student moves the thumb tip in the direction of action of the muscle being simulated, the angle between index finger and thumbs is maintained at 90 degrees. The student is then able to "feel" the deflection of the line of sight in real time. Diagrams and anatomical models [right] of the relevant muscles are available for reference in practical sessions.

Implementation and efficacy

At St George's, the finger guns method is first introduced in a traditional lecture setting, integrated with an anatomical review of the eye and the extraocular muscles. This is followed up by a practical session with student facilitators, supported by written materials and interactive quizzes (Table 1).

Informal student polls at the end of each session suggest that at least 50-60% of students grasp the method immediately (i.e. in the initial lecture) – and that by the end of the semester more than 90% of students understand how to use the method and find it a valuable aid to their learning.

The efficacy of the method will shortly be tested more formally and objectively using a split cohort of Canadian medical students in which traditional text book methods for learning and teaching eye movements will be compared directly with the 'finger guns' technique.

This will be assessed by a questionnaires asking students about their experience with the method, plus a written assessment of comprehension to allow an objective comparison. [*This work is being done with a graduate-entry medical student and will be published as a poster presentation*.]

Lecture (Theory)	The anatomy of eye movements is outlined in a traditional lecture and the 'finger guns' method is introduced to the group.
Practical session (Practice)	A small-group teaching session (two days after the lecture) provides an opportunity for students to try out the method for themselves, with a facilitator.
Written notes (Consolidation)	Students find it useful to have a permanent learning resource, describing the anatomy of eye movements and explaining the finger guns method.
Revision Quiz (Self-test)	Two formative, picture-based quizzes are delivered in the middle and at the end of the Semester, giving an opportunity to check understanding.

Table 1: How the method is introduced and tested. An initial lecture is used to introduce the technique, followed up by a 'hands-on' practical session, together with written reference materials and an informal, self-test quiz. The picture quiz is interactive and informal, with book token prizes awarded for the best-performing students.

Potential problems

Some students initially struggle to understand the method, particularly after the introductory lecture (before they have had a chance to try it out for themselves). This is usually for one of two reasons:

(i) they do not perceive themselves as 'kinaesthetic learners' and/or feel reluctant to try a novel method of learning that they are not familiar with

(ii) there is a problem with their technique (from experience, this is most often one of a small number of common 'pitfalls' such as holding the hand in the wrong position, forgetting the line of action of a particular muscle, or failing to maintain the thumb at right angles)

Each of these problems is readily resolved in the follow-up sessions: common pitfalls are addressed specifically and (peer-tutor) facilitators encourage students to try the method in the practical.

This proactive approach, based on experience with the technique, minimises misunderstanding and maximises the proportion of students who ultimately finding the method valuable. Feedback suggests that students *do* find it useful and many have commented that they use it during exams.

Publications and dissemination

Having created a novel method for teaching the biomechanics of eye movements, I am very keen to publish and disseminate the technique to a wider audience. This is being done in a number of ways:

Journal article publication

Together with graduate entry medical student Michael Esterlis, I have co-authored an educational article outlining the method and explaining how to implement it. The manuscript has recently been submitted to *Anatomical Sciences Education*, a Journal of the American Society of Anatomists.

Creation of free online videos

To help disseminate the method as widely as possible, I am currently working with a team of medical students and junior doctors to create two educational videos for the HippocraTV You Tube channel (Fig. 4). This is an on-line learning platform for medical and biomedical science students, which currently has over 20,000 subscribers from the UK and overseas. The videos are currently in the early production stages and are due to be released in April 2018 (http://www.hippocratv.com/).

Text book publication

Finally, to help maximise dissemination and potential use of the method across the UK (and hopefully beyond) a description of the technique will appear as an appendix in the second edition of the author's text book of clinical neuroscience (1st ed published by Churchill-Livingstone, 2014).

Fig. 4: Dissemination of the method. Two educational videos are in production (i) reviewing the anatomy of eye movements and (ii) introducing the finger guns method. [Publication: April 2018, HippocraTV You Tube channel.]

Reflections

The traditional concept of fixed 'learning styles', reviewed by Romanelli (2009), suggests that students preferentially learn in particular modalities (e.g. visual vs. kinaesthetic vs. auditory).

Although this idea has been very influential in bioscience education for many years now, it has recently been heavily criticised, with a growing body of opinion that individual learning styles may not in fact exist (Paschler et. al., 2008; Reiner and Willingham, 2010; Walsh, 2007).

Whilst this may well be true, I nevertheless believe that it is valuable to use a mixture of approaches to teaching - including kinaesthetic methods - but that we should match these to the particular topics for which they are most suitable, rather than aiming them at a specific sub-set of students.

In my own teaching, kinaesthetic learning is used selectively and sparingly, together with a mixture of many other approaches (e.g. analogy, metaphor, mnemoics and anecdotes) – with the constant and over-arching aim of emphasising comprehension over rote learning, promoting deep rather than surface learning, and - most importantly – inspiring excitement and interest in the subject.

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