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# A three dimensional view of stereopsis in dentistry

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Does dentistry require the three-dimensional information afforded by binocular vision? Stereopsis and its role in dental practice has been a topic of debate in recent editions of British Dental Journal (BDJ) [1,2]. These discussions are particularly timely as they come at a point when virtual reality simulators (often relying on 3D stereo-projected images to create "realistic" dental environments) are becoming increasingly popular in the education of tomorrow's dentists [3–5]. Such devices have raised questions about whether stereo-projected images are a necessary feature of simulators [6–8]. This relates to the larger issue of whether an ability to perceive the information that arises specifically from a binocular view should be a prerequisite for surgical training [9,10].

Syrimi and Ali's recent review of the literature[1] concluded that "stereopsis should not be considered a requirement for dental training". This conclusion was supported by a subsequent personal account from an experienced practitioner with a 'lazy left eye' and a history of dismal abilities in hitting moving targets, including "high velocity tennis, cricket and squash balls" [2]. Duffy drew attention to the fact that he had "made a reasonable success of [his] career" and thus "anyone with similar issues reading the article should take some comfort from this". Nevertheless, we argue that Syrimi and Ali's conclusion is potentially indefensible on the basis of the (absence of) evidence provided in their review. We further suggest that the use of anecdotal reports to encourage trainees with known perceptual deficits to enter the profession of dentistry is not compatible with a health service that has patient safety as its primary objective – especially when 'career success' is considered an outcome measure. We will briefly outline the grounds for our arguments below.

It is first necessary to define what is meant by the term stereopsis (an omission in the review of Syrimi and Ali who appear to regard the term as

synonymous with ‘depth perception’). Stereopsis can be defined as the information regarding three dimensional object structure which is made available through retinal image differences (differences that arise because the eyes are horizontally separated by approximately 6cm in humans). Many studies have shown that: (i) horizontal disparities can provide information about the slant, curvature and depth of proximally fixated objects [11–13]; (ii) humans use this information [14–16]; (iii) the use of stereopsis (and other ‘cues’) is task dependent [17,18] (with the binocular information regarding the time to contact of an approaching ball [19,20] being used in a different manner to the information used - for example – in gauging object curvature [21]). Thus, a fundamental and important question arises from the existing literature – is stereopsis a necessary cue in dental tasks?

The implicit reasoning within Syrimi and Ali’s review centres on the conjecture that if individuals with stereo-deficits can “function effectively as dental students and practitioners” then it follows that stereopsis is not needed within dentistry. This conjecture appears reasonable and seems to rest on the valid propositional logic of modus tollens. We suggest, however, that Syrimi and Ali’s position is actually based on an absence of evidence- which is not the same as ‘evidence of absence’. One major difficulty with Syrimi and Ali’s proposition is that they have not defined what constitutes a stereo-deficit or ‘effective function’. Moreover, there is a lack of acknowledgement that stereo-deficits can arise through a number of aetiological routes (‘lazy eye’ has a similar level of diagnostic precision as ‘tooth rot’). Unfortunately, satisfactory definitions of effective function cannot be achieved without understanding how stereopsis is used (or not) in specific dental tasks (e.g. drilling teeth) and measuring the minimum thresholds of stereo-perception if

stereopsis is required. In our opinion, an absence of studies on this topic cannot logically be used to support the notion that stereopsis is not important.

The discipline of psychology has a long history of empirically investigating the task-specific use of perceptual cues [22–25]. There is no doubt that stereopsis creates a strong phenomenological sense of three-dimensional space (a fact that is often used to mask the absence of interesting storylines in films such as *Avatar*). But the critical issue is whether the cognitively penetrable sense of an object's stereoscopic dimensions is necessary in dental decision-making (e.g. judging the extent of dental caries). There is also no doubt that stereopsis supports a number of skilled human behaviours – i.e. it can provide essential information for feedforward and feedback motor control mechanisms [26–28]. The crucial issue in this instance is whether specific dental tasks require this perceptual information (or whether other available cues will suffice). As Syrimi and Ali's review demonstrates, there is a notable and disappointing lack of investigation into this topic within the dental literature.

From a patient safety perspective, we would argue that any known perceptual or motor deficit should be an exclusion criterion for dental training unless there is unequivocal evidence that such deficits do not impact on dental task performance. The argument against such an approach relates to the possibility of discriminating against an individual with a physical impairment that is not relevant to the core skills needed within dentistry. We would suggest that such concerns are legitimate but from a safety perceptive the dental profession is subject to onus probandi – it is reasonable for the public to expect that entrants to the dental profession have no known perceptual-motor deficit unless it has been unequivocally demonstrated that a particular deficit does not impact negatively on any aspect of patient care (with absence of evidence not constituting an adequate demonstration).

In conclusion, we observe that screening for stereo-deficits is easily implemented (with well-defined thresholds of abnormality established) and suggest that it is hard to justify ‘turning a blind eye’ to a potential impediment to dental proficiency. This reasoning raises the more general (and difficult to address) issue of testing eye-hand coordination competency. We submit that is incumbent on the dental profession to identify the key perceptual-motor abilities underpinning dental competency so that individuals with known perceptual and motor deficits do not embark on a career that may impact negatively on patient care.

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