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COMMENTARY

Spatial ability in radiologists: a necessary prerequisite?

D BIRCHALL, MB BChir, FRCR

Department of Neuroradiology, Regional Neurosciences Centre, Royal Victoria Infirmary, Newcastle upon Tyne, UK

Address correspondence to: Dr Daniel Birchall
E-mail: *daniel.birchall@nuth.nhs.uk*

ABSTRACT

Visuospatial ability is fundamental to the cognitive understanding of the three-dimensional environment and is widely recognized as an important skill in the performance of challenging visuospatial tasks. Its contribution to attainment and performance in a variety of professional disciplines is recognized, but there is relatively little known in relation to its relevance in radiological practice. On the basis of a review of the existing cognitive psychological literature and on the basis of the author's own observations, and on the assumption that spatial ability is of increasing and fundamental importance to high-level performance as a radiologist, it is proposed that consideration should be given to the testing of visuospatial ability as part of the selection process for prospective applicants to radiology training programmes.

Our understanding of the world and our interaction with it is based on the creation of three-dimensional mental representations of objects within the environment around us. This is fundamental to the solving of tasks in everyday life—whether negotiating busy traffic or peeling a potato. Such understanding is dependent upon the cognitive processing of visual projections arriving at the retina and the creation of a mental understanding of how objects relate to each other in time and space.

In a more applied way, this cognitive process is also involved in other situations in which mental representations of objects are formed based on varying forms of two-dimensional visual display. This is of relevance especially to a wide spectrum of professional disciplines, including engineering, architecture, mathematics, computer sciences, natural sciences and a variety of medical disciplines—particularly radiology and surgery—and relates to the process by which internal three-dimensional representations of objects are mentally generated based on the assimilation and integration of a series of two-dimensional spatial displays.[1,2] One famous example of the mental visualization of a complex three-dimensional shape, based on the interpretation of two-dimensional data (X-ray diffraction images), was the formulation of the complex double helical structure of DNA by Crick and Watson in 1953. The ability to spatially visualize is becoming increasingly important with the increasing complexity and prevalence of computing power, graphics and digital display technology, reflecting a requirement for the performance of highly demanding visual–spatial tasks.[2]

The perception and understanding of the spatial relationships between different objects depend on spatial ability. This is a form of intelligence that is distinct from, although heavily integrative with, other intelligence subtypes, such as logical—mathematical; verbal—linguistic; and bodily—kinaesthetic abilities. Spatial ability involves the capacity to encode and cognitively manipulate perceived three-dimensional forms, whether based on stereoscopic retinal display or on the assimilation of a series of two-dimensional electronic display images.

It has been appreciated for some time that spatial ability strongly correlates with attainment and performance in a wide variety of science, technology, engineering and mathematics (STEM) disciplines:[3] a large number of studies have demonstrated a clear linkage between psychometrically assessed spatial ability with career progress and performance of complex, discipline-related tasks, even when accounting for other forms of intelligence.[4] Such studies prompted Gardner,[5] an influential American professor of psychology, to state that "it is skill in spatial ability which determines how far one will progress in the science".

Although there are many studies relating spatial skills to performance in STEM disciplines,[1–4] the study of its relevance to medicine has been relatively neglected. Yet, it is clear that spatial cognition is fundamentally important in medicine, not least to the understanding of medical images, which in essence are a series of two-dimensional representations of three-dimensional objects. The interpretation of such representations is centrally reliant on spatial ability:

the ability to comprehend complex three-dimensional structures based on the assimilation of, in many cases, large numbers of two-dimensional image slices.

A relatively small number of studies relating to the medical field have been published. For example, the importance of spatial cognition as a predictor of attainment in dentistry has been recognized for many years, with one study showing a significant correlation between psychometrically evaluated visuospatial skills with the performance of restorative dental procedures.[6] Based on this and other studies, the Dental Admissions Test for university courses in the USA includes the Perceptual Aptitude Test—an examination of spatial ability using a variety of formal psychometric techniques. Visuospatial tests also form part of the dental admissions procedure at some UK universities.

A further study, of student performance at medical schools, demonstrated that psychometrically evaluated spatial skills correlate with better understanding and achievement in anatomy classes.[7] This and similar studies suggest that spatial ability is fundamental to the construction of an accurate three-dimensional mental model of anatomical structures.

A number of studies[8–10] have undertaken analyses of spatial ability—as assessed by formal psychometric testing—in the field of surgery, and several studies have shown significant correlation with the performance of complex surgical tasks, including laparoscopic dexterity tasks. Correlations have been shown with certain tests of spatial ability, including mental rotation and paper-folding tests. Such studies suggest that the ability to mentally visualize inferred anatomical structures and associations in three-dimensions plays an important role in the development of surgical competencies.

Despite such studies, the prevailing training model in surgery is a skill-based one, in which practice and experience are considered to be the primary requirements in the attainment of surgical expertise. With good reason, it is broadly considered that individuals of all abilities can acquire the necessary skills and attain a sufficient standard in surgery through practice and that general intelligence and motor skills may be more important than spatial ability at the onset of training. This is also consistent with the suggestion that the impact of spatial abilities reduces with increased experience and domain-specific knowledge.

In the field of radiology, it has similarly been suggested that the dominant requirements for attainment in the speciality relate to experience and the development of speciality-specific knowledge.[11] The potential importance of spatial ability in radiology has, however, been highlighted,[12] and the suggestion made that recognition of visual patterns and the linkage of spatial skills with specialist semantic knowledge represents a fundamentally important ability codependence. Certainly, the developments of radiological and computing technologies, and the increasing complexity of radiological visualizations and projectional syntheses, result in very highly demanding three-dimensional spatial visualization tasks, necessitating high levels of inherent spatial ability.

There have been very few and only semi-structured studies of spatial ability in radiologists.[13,14] Prominent among these is a 1984 article by Smoker et al[13] in which a correlation was reported between scores in a visual form reconstruction test and performance of radiology residents in a faculty training programme. Anecdotally, we have at our institution assessed visual–spatial ability in a cohort of consultant radiologists using a complex paper-folding test and found a weak correlation between experience and test score. Otherwise, there has been very little formal psychological study of the role of spatial skills in the practice of radiology. Indeed, it has been stated as recently as 2012 that "No one has examined the role of psychometrically assessed visual skills in radiology practice".[1]

Despite this, the limited information available does suggest that there may be a correlation between spatial ability and radiologist performance and experience. The observations lend support to the proposal that along with semantic speciality-specific knowledge, spatial ability is a fundamental skill required for expertise in radiology practice. It may also be the case that spatial skills are malleable and learned; it seems plausible that the day-to-day use of spatial visualization in radiology practice results in the development of increasingly highly honed spatial ability.

Such observations do raise the following important questions: should psychometric testing of spatial ability be used to help select radiology trainees for admission to training programmes? Although the existing model of training assumes that almost all trainees will eventually reach an acceptable and appropriate standard of expertise with practice and with acquisition of adequate semantic knowledge, it could equally be argued that trainees will reach a higher level of expertise more quickly if there is pre-existing skill in cognitive visual–spatial processing. Would it not be reasonable, given the increasing complexity of radiological imaging techniques and visualizations, for some assessment of spatial ability in prospective radiological trainees? And assuming a basic importance of spatial ability in radiological practice, should there be a place within training programmes for dedicated spatial skills training?

There is certainly a need to formally examine the relationship between psychometrically assessed spatial ability and radiological expertise, but it may be that there is already sufficient information in the existing literature relating to STEM, medical and dental disciplines to allow these questions to be answered in the affirmative.

In conclusion, on the basis of review of the existing cognitive psychological literature and based on the assumption that spatial ability is of increasing and critical importance to high-level performance as a clinical radiologist, it is proposed that consideration should be given to the testing of visuospatial ability as part of the selection process for prospective applicants to radiology training programmes.

And, furthermore, when one is asked about the necessary attributes that make an expert radiologist, as well as knowledge, experience, reasoning, effective communication and interpersonal skills, one should perhaps also say that first and foremost, like Crick and Watson, we need to be expert visuospatial thinkers.

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