Mammography to Tomosynthesis: Comparing Two-Dimensional to Three-Dimensional Visual Search in Radiologists and Undergraduates

Stephen H. Adamo[1] Ph.D., Justin M. Ericson[1] Ph.D., Joseph C. Nah[1] MA, Rachel Brem[2] MD, & Stephen R. Mitroff[1] Ph.D.
[1]Department of Psychology, The George Washington University
[2]Department of Radiology, The George Washington University

Rationale:

Radiological techniques for breast cancer detection are currently transitioning from relying primarily on mammography, two-dimensional (2D) image of breast tissue, to being complemented by tomosynthesis, a technique that creates a three-dimensional (3D) image of the breast. With tomosynthesis, a radiologist can search through multiple layers of depth to evaluate the image(s) with greater fidelity. While there is a clear benefit of tomosynthesis with a reduction in false positives (e.g., Durand et al., 2015), it can take significantly longer (e.g., Bernardi et al., 2012) and it is unclear what other factors of a 3D search environment might affect performance.

This project sought to better understand 3D search by evaluating commonly studied factors in 2D search (e.g., response time and search accuracy) in both professional radiologists and non-professional searchers with the ultimate goal of creating a search environment that can inform radiology by using non-radiographs and non-professionals. To accomplish this, we created a 3D search program that emulates tomosynthesis while allowing for flexibility to manipulate factors such as set size (i.e., number of items in the display) and clutter.

Methods:

Data were collected from 29 radiologists from the 2016 Radiological Society of North America conference and 31 undergraduate students from The George Washington University. Observers were asked to search in both 3D and 2D environments. Importantly, the program emulated tomosynthesis, but did so with simplified stimuli that was accessible to both professional and non-professional observers. Observers had 60 seconds per trial. In the 3D images, they could traverse throughout the sphere, moving from one search display "slice" to the next and search for a target "T" amongst distractor "Ls" (see Figure 1B). On half of the trials, the 3D sphere was "compressed" into a 2D image akin to how a breast image can be viewed using tomosynthesis or as a mammogram (Figure 1A). There were 24 trials divided equally between 3D and 2D with targets present on half of the trials in each condition.

Results:

A series of 2x2 ANOVAs revealed a main effect of condition (3D vs 2D)—professionals and non-professionals had significantly more correct rejections in target-absent trials, more hits in target-present trials, and had fewer false alarms (i.e., false positives) in 3D compared to 2D. There were no significant between-subject (professionals vs. non-professionals) or interaction effects. Importantly, observers also took significantly longer to search on target-absent trials in 3D compared to 2D with no significant between-subject or interaction effects.

Conclusions:

The results demonstrated a clear reduction in false alarms (false positives), improvement in hit rates, and improvement in correct rejections when searching in 3D. However, observers took longer. Theoretically, these results suggest a potential speed/accuracy trade-off when searching in 3D compared to 2D. Practically, the results typically found when comparing tomosynthesis to mammography were obtained within computerized 3D and 2D searches with both professionals and non-professionals. This program might provide an easier alternative to running radiologists with real medical images and can help to further identify key advantages and potential pitfalls of tomosynthesis in relation to mammography.

Figure 1

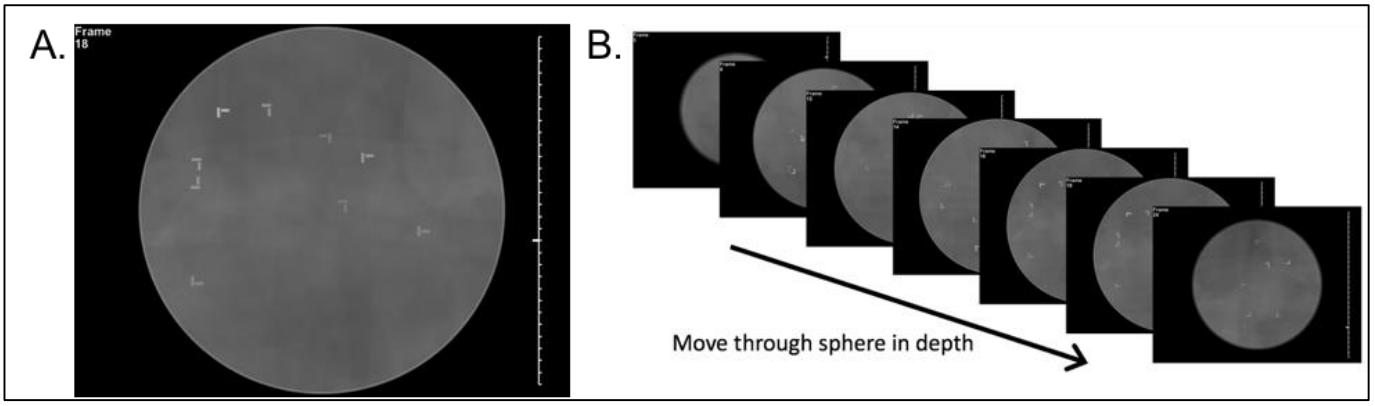

Figure 1. (A) Sample image of a single layer of the search space. A target "T" is on the right. (B) depictions of the 3D nature of the search space and how observers can search from one slice to another in the sphere.