Dual-View Displays for Minimally Invasive Surgery: Does the Addition of a 3-D Global View Decrease Mental Workload?

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Background
Reduced visual and haptic cues, along with frame-of-reference problems can cause surgeons to become disoriented while performing laparoscopic surgery. Most laparoscopic surgeries are performed via the use of a limited, single-scope, two-dimensional (2-D) view presented on a monitor in the operating room. Currently surgeons must mentally stitch together the individual snapshots as seen through the limited view of the laparoscope to create a complete situation model to understand where they are and where they need to go (Cao & Milgram, 2000). Because surgeons may easily become disoriented due to mismatches in frames of reference between what is seen on the display and where the surgeon is positioned, creating accurate situation models may be difficult. Consequently, there is demand for the availability of three-dimensional (3-D), global views.

Providing surgeons with both a local (scope) view as well as a computationally generated global view based on preoperative MRI scan data (Yang, et al., in press) may decrease workload and allow for more complete and accurate mental models; however previous research shows that people often fail to choose the correct display for the task at hand (Bailey, Carswell, Grant & Basham, 2007; Delucia, Hoshins & Griswold, 2004) leading to possible increases in mental workload and task completion time.

The following, preliminary study explored the potential costs and benefits of providing a supplemental 3-D global view of the surgical field on participants, workload, performance efficiency and acquired spatial models during simulated surgical search and navigation tasks.

Method
Participants
Thirteen graduate students (8 females, 5 males) participated in this preliminary study.

Equipment
Physical 3-D model – A 3-D resin organ, produced using the same underlying 3-D surface model as used to generate the model in the navigation tasks, was used for the spatial-reconstruction task.

Results

- **Search-and-Traversal Task**
  - A t-test comparing target accuracy between display types and an ANCOVA (controlling for gender, search-and-traverse workload, and practice) comparing RMSE between display types revealed a trend for increased accuracy (t(11) = 1.61, p = .063) and decreased workload (F(1,8) = 1.99, p = .327, partial $\eta^2 = .12$) in the dual-view display condition.

- **Spatial Reconstruction Task**
  - A t-test comparing target accuracy between display types and an ANCOVA (controlling for gender, search-and-traverse workload, and practice) comparing RMSE between display types revealed a trend for increased accuracy (t(11) = 1.61, p = .063) and decreased workload (F(1,8) = 1.99, p = .327, partial $\eta^2 = .12$) in the dual-view display condition.

Conclusions and Future Research
- Trends for decreased workload and increased accuracy support the addition of composite, surgical panoramas (global view) in some search and recall tasks.
- Future research should consider the costs of participants/users choosing or relying on the global view when it is not necessitated by the task.
- Research should also pursue analysis of eye tracking data to better understand when participants take advantage of the supplemental display.
- Decisional guidance and training on how and when to use the displays should be explored.
- In order to more closely simulate laparoscopic surgical conditions and workload, subsequent studies should further restrict the scope-view display and focus on using participants who are surgeons or medical students.

References


