

Hand-eye Coordination in Simulated Laparoscopic Surgery
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The spatial arrangement of the endoscopic camera with respect to the surgeon and patient in laparoscopic surgery often requires surgeons to adapt to variable visuomotor mappings. This affects the perception of position and orientation of organs and tissues, and consequently the accuracy of manipulation and success of the surgical procedure. The purpose of this study was to examine the role of hand-eye coordination, and the effects of misaligned endoscopic viewing perspectives on performance, during simulated laparoscopic surgery. A task space consisting of 5 vertical pins of various heights was placed in a laparoscopic trainer box with a rigid endoscope and laparoscopic graspers. The endoscopic image of the task space was projected onto a TV monitor. Based on this image, subjects were directed to point and touch each pin in turn using the laparoscopic graspers. The viewing conditions were varied by positioning the endoscope at 0, ± 45 , ± 90 , and 180 degrees with respect to the task space, and by rotating the endoscope along its long axis at 0, ± 45 , and ± 90 degrees. A total of 30 subjects participated in the study. It was found that, regardless of the position of the camera with respect to the task space, performance was affected only by the orientation of the endoscopic image of the task space. Subjects had longer performance times when the image was inverted than when it was aligned to the natural viewing perspective. The task presented the least difficulty when the image was rotated by 0 or 180 degrees, and the most difficulty when the image was at ± 90 or ± 45 degrees. This seems to suggest that hand-eye coordination is achieved by mapping the hand space directly to the display space, without going through the intermediate transformations imposed by the physical arrangements of the camera position and orientation. This research has important implications for the design of imaging systems and tools in laparoscopic surgery, as well as for the training of visuomotor co-ordination in remote manipulation.