The American Journal of Surgery 195 (2008) 210–213
Association for Surgical Education

Do novices display automaticity during simulator training?

Dimitrios Stefanidis, M.D., Ph.D.[a,*], Mark W. Scerbo, Ph.D.[b], Cathy Sechrist, B.S.[a], Ana Mostafavi[a], B. Todd Heniford, M.D.[a]

[a]*Department of Surgery, Carolinas Medical Center, Charlotte, NC, USA*
[b]*Department of Psychology, Old Dominion University, Norfolk, VA, USA*

Manuscript received April 29, 2007; revised manuscript August 24, 2007

Podium presentation at Surgical Education Week, Washington, DC, April 10, 2007

Abstract

Background: The objective of this study was to investigate whether novices improve their ability to develop multitask (ie, automaticity) with accumulating experience on a simulated laparoscopic task.
Methods: In this prospective study, novices (12 premed students) trained for 4 months in laparoscopic suturing. Simultaneously with suturing, participants performed a visual–spatial secondary task to assess their spare attentional capacity. Trainees were required to achieve expert-derived levels in both suturing (520 score) and the secondary task (target 73%). Their performance was assessed with objective scores, and their ability to multitask during training was examined.
Results: After 10 ± 5 hours and 84 ± 41 repetitions, participants demonstrated improvements in their suturing (70%, $P < 0.001$) and secondary-task performance (16%, $P = 0.08$) compared with their baseline scores. During the study period, 11 of 12 participants achieved suturing proficiency, but no one achieved secondary-task proficiency. Longer training times correlated with higher secondary-task scores ($r = .68$, $P < 0.02$), and participants who performed >100 repetitions (n = 4) achieved higher secondary-task scores ($P < 0.03$).
Comments: This study provides evidence for improved automaticity at advanced stages of simulator training. Although novices achieve simulator proficiency after relatively short training durations, the attainment of automaticity requires substantially longer training periods. Further study of this concept is warranted and is currently underway.

Keywords: Automaticity; Laparoscopy; Secondary task; Simulators; Skills Training; Proficiency

Evidence regarding the educational value of simulators in surgery is accumulating rapidly in the surgical literature [1–3], and most surgical training programs strive to incorporate them in their residency curricula [4,5]. Simulators allow repetitive and deliberate practice in a safe, nonthreatening environment, which, coupled with performance feedback, facilitates trainee learning and lessens the learning curves of new procedures. Although multiple simulators have been validated as effective training tools [1], curriculum development is lagging, and considerable work is still needed to determine the best methods for training.

Proficiency-based simulator curricula set expert-derived performance goals that help tailor training to meet individual needs and have been proven effective and efficient in improving the operative performance of trainees [3,6,7]. Nevertheless, such curricula are subject to the limitations of the currently available assessment methods and to our incomplete understanding of surgical expertise [8]. Most proficiency-based studies have used small numbers of local experts to establish proficiency levels and base performance assessment on the traditional metrics of time and errors, which may not be ideal for the measurement of superior performance [9]. Such metrics provide little or no information about the level of effort a performer must invest to accomplish a task [10,11]. Hence, although 2 performers may produce equal results on measurements of time and accuracy, they may have substantial differences in workload and attentional demands that reflect differences in experience, true skill level, and learning [10,11]. Importantly, incomplete metrics may hinder the ability of individuals to obtain maximum benefit from training with a simulator.

* Corresponding author. Tel.: +1-704-355-6220; fax: +1-704-355-5619.
E-mail address: dimitrios.stefanidis@carolinas.org

0002-9610/08/$ – see front matter
doi:10.1016/j.amjsurg.2007.08.055

First described by Schneider and Schiffrin, the term "automaticity" refers to the ability to perform a task with little effort and few attentional resources [12–14]. Highly experienced individuals (experts) can often perform multiple tasks simultaneously with little or no performance decrement, whereas novices often struggle with a new and difficult task, and their performance is severely impaired when they attempt to engage in another task at the same time. Based on this principle, secondary-task measures that address attentional time-sharing have been developed and may yield a more comprehensive assessment of performance and learning compared with the traditional metrics of time and accuracy. In an effort to apply this theory to simulator training, we previously demonstrated that a visual–spatial secondary task that measures spare attentional capacity can distinguish among levels of laparoscopic expertise even when the traditional metrics of time and accuracy fail to do so [9].

The objective of this study was to evaluate whether novices display automaticity during simulator training. We aimed to assess whether their secondary task scores that are reflective of multitasking ability would improve with training over time and when this would occur in relationship to the achievement of speed and accuracy goals.

Methods

Individuals with no previous laparoscopic or simulator experience (12 premed students) were enrolled in an Institutional Review Board–approved simulator training protocol. Training was performed at the Skills Laboratory of the Division of Gastrointestinal and Minimally Invasive Surgery of the Carolinas Medical Center in Charlotte, North Carolina, and ran for 4 months.

Participants voluntarily consented to the study, completed a baseline questionnaire, watched an introductory video tutorial of intracorporeal suturing and knot tying (primary task), and had their baseline performance recorded on the primary task and on a secondary task. The secondary task, which we previously described in more detail [9], was a computer-generated visual–spatial processing task that assessed spatial memory resources and attention [15,16]. Subjects had to monitor a successive series of white solid squares displayed on a laptop computer screen positioned near the main laparoscopic monitor. The squares appeared at random on either the right or left side of the screen once every second. Participants were required to respond by stepping on a foot pedal when a pattern of three successive squares appeared on the right side of the screen (target). Targets occurred three times per minute at random intervals. All correctly identified targets were logged as correct detections; the percentage of correct detections constituted the secondary task score [9]. In a previous study, we observed that when this secondary task was performed simultaneously with the primary task, it reliably reflected the spare attentional capacity of the performer, providing an alternative index of the participant's expertise with the primary task (in this case, intracorporeal suturing and knot tying) [9].

Participants practiced laparoscopic suturing and knot tying on the Fundamentals of Laparoscopic Surgery suturing model [17,18] in a videotrainer simulator during weekly 1-hour sessions until they achieved predetermined expert-derived proficiency-levels on both the primary and secondary tasks. Dual-task performance (simultaneous performance of primary and secondary tasks) was required for 10 minutes during each hourly training session. After achieving the suturing proficiency score, participants practiced under dual-task conditions multiple times per training session.

Suturing performance scores were calculated by objective evaluation of each created knot based on time, accuracy, and security errors using the formula: score = 600 − (time + 10 × accuracy errors + 10 × security errors) [3,7]. A cut-off time of 10 minutes (600)/repetition was used, and the proficiency level was set at a score of 520 [9]. Secondary task performance was assessed by the percentage of correct detections of targets with a proficiency level set at 73% [9]. These training goals were posted at each training station to motivate trainees.

Deliberate practice was encouraged, and an expert provided participants with performance feedback as needed during training. Furthermore, trainees had liberal access to video tutorials that detailed the technique and common pitfalls. They were instructed to give priority to performing the primary task and attend to the secondary task as attentional resources allowed.

All participants were asked to evaluate their training experience by completing a questionnaire at study conclusion. The NASA-TLX questionnaire [19] was used to measure the participants' subjective ratings of workload experienced during training. In addition, we recorded and analyzed participant demographics, baseline operative and simulator experience, training duration, total number of repetitions, time to proficiency, frequency of achieving the proficiency score, and suturing and secondary-task performance during each training session. Paired and unpaired Student *t* test and Pearson's correlation were used for statistical analysis (SigmaStat 3.0 statistical software; SPSS, Chicago, Illinois); $P < 0.05$ was considered significant.

Results

Participant baseline characteristics are listed in Table 1. During the 4-month study period, participants completed 10 ± 5 hourly training sessions and performed 84 ± 41 repetitions. By study completion, participants demonstrated performance improvement in both primary and secondary tasks (Fig. 1). Eleven (92%) participants achieved the proficiency level in suturing an average of 14 ± 19 times. In

Table 1
Participant characteristics

N	12
Age (y)	20 ± 1
Men-to-women ratio	1.4:1
Right-hand dominance (%)	92
Previous operative experience*	0 ± 0
Previous simulator experience*	0 ± 0
Video game ability*	10 ± 6
Billiards ability*	8 ± 4

* Ratings on a 20-point Likert scale.