Surg Endosc (2008) 22:196–201
DOI 10.1007/s00464-007-9452-0

# Experienced surgeons can do more than one thing at a time: effect of distraction on performance of a simple laparoscopic and cognitive task by experienced and novice surgeons

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Published online: 20 August 2007


**Abstract**

*Background* While operating, surgeons are required to make cognitive decisions and often are interrupted to attend to questions from other members of the health care team. Technical automatization may be achieved by experienced surgeons such that these distractions have little effect on performance of either the surgical or the cognitive task. This study assessed the effect of adding a distracting cognitive task on performance of a basic laparoscopic skill by novice and experienced surgeons.

*Methods* In this study, 31 novice (medical students in postgraduate years [PGYs] 1–2) and 9 experienced (fellows/attendants and PGYs 4–5) laparoscopic surgeons practiced the Fundamentals of Laparoscopic Surgery (FLS) laparoscopic peg transfer task until their scores stabilized. The mean normalized score after five repetitions then was recorded. The subjects also were tested on the number of mathematical addition questions they could answer in 1 min. This was repeated five times, with the mean number of questions attempted and the accuracy (% correct) recorded. The laparoscopic and addition tasks then were performed concurrently five times. Data, presented as mean ± standard deviation, were analyzed using Student's *t*-test. A $p$ value less than 0.05 was considered statistically significant.

*Results* After practice to stable peg transfer performance, the baseline peg transfer score was higher in the experienced group (98 ± 6 vs 87 ± 12; $p < 0.01$). There were no baseline differences between the groups in the number of math questions attempted in 1 min (10 ± 2 vs 9 ± 2; $p = 0.55$) or the number of correct answers (9 ± 3 vs 8 ± 3; $p = 0.36$). The comparison of baseline performance and dual-task performance showed that the experienced surgeons had no decline in peg transfer score (98 ± 6 vs 97 ± 6; $p = 0.48$), number of questions attempted in 1 min (10 ± 2 vs 9 ± 3; $p = 0.32$), or number of correct answers (9 ± 3 vs 8 ± 3; $p = 0.46$). In contrast, dual-tasking among the novices was associated with a decrease in the number of questions attempted (9 ± 2 vs 8 ± 2; $p < 0.01$) and the number of correct answers (8 ± 3 vs 7 ± 2; $p = 0.02$), and with no change in the peg transfer score (87 ± 12 vs 88 ± 8; $p = 0.38$) compared with baseline.

*Conclusions* Distraction significantly decreased a novice's ability to process cognitively based math problems, whereas there was no effect on experienced subjects. This occurred despite the fact that the novice group had practiced to high-level peg transfer scores at baseline. This suggests that the experienced surgeons had achieved automatization of the peg transfer basic surgical skill to a level that cognitive distraction did not affect performance of either task. The experienced surgeons were able to attend equally to both tasks, whereas the novices attended to the surgical task at the expense of some aspects of cognitive task performance.

Presented at the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), Las Vegas, Nevada, USA, April 2007

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**Keywords** Automatization · Cognitive distraction · Dual-tasking · Surgical education · Surgical performance · Surgical simulation

Modern surgical practice often requires multitasking, and distractions are frequent. While operating, surgeons are interrupted an average of 13.5 times per case [1]. Distractions often are cognitive in nature and require immediate attention. Examples include calls from the ward, consultations from the emergency department, ringing pagers, door opening, and conversations not pertinent to the surgical procedure [1].

It is unclear how distractions affect surgical performance and to what extent experience or practice affects the impact of distracting influences. Although experimental psychology literature suggests that a slowing effect on performance, termed the "psychological refractory period" (PRP), exists in most dual-task situations [2, 3], experiments examining the effect of distraction on surgical performance have failed to show any statistically significant effect [4, 5].

It might be expected that the presence of a distracting stimulus would invariably affect the performance of the primary task negatively. However, reported data regarding the outcomes of dual-tasking are inconsistent. In fact, depending on the types of tasks and study design, a distracting stimulus may have a positive, neutral, or negative impact on the performance of a primary task [2, 5, 6].

Experience may strongly affect the impact of a distracting cognitive task on performance of a technical skill because repeated practice allows many skills to become automatic or "automatized" [7]. It is unclear whether experience or practice allows surgical skills to become truly automatized [2]. To our knowledge, no previous studies have examined the effect of experience on a surgeon's ability to negate distracting influences during performance of a primary surgical task.

In the current study, the effect of a cognitive distracting task on the performance of a simple laparoscopic task was examined in relation to the level of surgical experience. We hypothesized that experienced surgeons would be better able to perform the cognitive and technical skill tasks simultaneously if some degree of automatization of the technical skill had already been achieved.

## Materials and methods

A total of 31 novice (27 medical students and residents in postgraduate years [PGYs] 1–2) and 9 experienced (fellows/attendants and PGYs 4–5) laparoscopic surgeons volunteered for the study at the McGill University Health Centre (Table 1). The study was approved by the Research Ethics Board, and informed consent was obtained.

**Table 1** Subject demographics

| | Experienced ($n$ = 9) | Novice ($n$ = 31) |
|---|---|---|
| Gender (M/F) | 6/3 | 13/18 |
| Students | 0 | 27 |
| PGY 1–2 | 0 | 4 |
| PGY 3–5 | 4 | 0 |
| Fellow/staff | 5 | 0 |

PGY, postgraduate year

The subjects first performed the FLS peg transfer task. This simulated laparoscopic transfer task and the performance metrics have been previously described and validated extensively [8–12]. Briefly, the FLS simulator consists of a lighted, enclosed laparoscopic trainer box fitted with two 12-mm trocars (Surgiport; U.S. Surgical, Norwalk, CT) in a fixed position relative to the task materials. A stationary video camera (Sony Corp, Montreal, QC) is connected to a 19-in. monitor.

In the peg transfer task, six rings are picked up one at a time from a left-sided pegboard by the left hand (if the surgeon is right-handed) using a grasping forceps, transferred to a grasper in the right hand, and then placed sequentially on a right-sided pegboard. After all six rings have been transferred, the process is reversed, with the rings transferred from the right to the left hand. The task is always started with the nondominant hand, and then the reverse is done. Scoring rewards speed, with a penalty assessed whenever a ring is dropped outside the view of the camera. A short instructional video demonstrating the task was shown to each subject before task practice and performance.

In preparation for the study, the subjects were supervised as they repeated the peg transfer task at least five times and until three consecutive scores were reached with less than a 10% variation in the FLS score. The FLS scores incorporated time and error penalties. This was done in an attempt to reduce any "learning curve" effects [13]. The subjects then performed the peg transfer task five times, and normalized FLS scores were recorded.

After baseline peg transfer performance, the subjects performed the cognitive task, in which they answered as many addition questions as possible in 1 min. Questions were randomly generated by computer such that the addition questions were of "moderate difficulty" in that they required the subject to "carry a digit" (e.g., 25 + 56). This cognitive task was repeated five times, with the number of addition questions answered correctly in 1 min and the number of attempted questions recorded.

Finally, the surgical task was performed concurrently with the distracting arithmetic questions five times (dual task), with the peg-transfer scores and the computation results both recorded. The subjects were instructed that both tasks had equal importance. For both the single- and dual-task results, the mean of the five iterations was used in the analysis.

Data are expressed as mean ± standard deviation. Within the novice and experienced groups, baseline performance was compared with distracted performance using the paired, two-tailed Student's *t*-test. Novices were compared against experienced surgeons using the nonpaired, two-tailed Student's *t*-test. A *p* value less than 0.05 was considered statistically significant.

## Results

At baseline (single tasks), the experienced surgeons had significantly better normalized FLS peg transfer scores than the novices (98 ± 6 vs 87 ± 12; $p < 0.01$) (Table 2). This result occurred after the novice subjects had been allowed to practice until their scores had stabilized. Scores were considered to have reached plateau after at least five practices, and when there was no more than a 10% variation in three consecutive trials. The average plateau score of the novice group (85.9 s) did not differ significantly from the mean score of the experienced surgeons in a large multicenter database of FLS peg scores [12]. There were no statistically significant baseline differences between the experienced and novice groups in the number of math questions attempted in 1 min (10 ± 2 vs 9 ± 2; $p = 0.55$), the number of correct answers per minute (9 ± 3 vs 8 ± 3; $p = 0.36$), or the percentage of correct answers ($p = 0.06$) (Table 2).

When baseline single-task performance and dual-task performance were compared, the experienced surgeons showed no decline in peg transfer score ($p = 0.48$), number of questions attempted in 1 min ($p = 0.32$), number of correct answers ($p = 0.46$), or percentage of correct answers ($p = 0.6$) (Table 3). In contrast, dual-tasking among novices was associated with a decrease in the number of questions attempted ($p < 0.001$) and the number of correct answers per minute ($p = 0.02$) compared with baseline (Table 3). The novices had no statistically significant change in peg transfer score ($p = 0.38$) or percentage of correct answers ($p = 0.12$).

**Table 2** Baseline (single-task) performance of experienced and novice surgeons (mean ± standard deviation)

| Task | Experienced ($n = 9$) | Novice ($n = 31$) | *p* Value |
|---|---|---|---|
| Peg transfer score | 97.7 ± 6 | 86.8 ± 12 | 0.001 |
| No. of math questions/min | 9.5 ± 2 | 9.0 ± 2 | 0.55 |
| No. of correct math questions/min | 8.8 ± 3 | 7.9 ± 3 | 0.36 |
| Percentage of correct math questions | 91.6 ± 7 | 85.9 ± 10 | 0.06 |

## Discussion

This study found that the impact of a surgical and cognitive dual-task set on performance depended on the experience level of the surgeon. The data suggest that more experienced surgeons are able to perform both a surgical task and a cognitive task concurrently without interference, whereas novice surgeons attended to the surgical task to the detriment of cognitive task performance. Cognitive distractions did not seem to affect the performance of a simple surgical task regardless of experience level. These results may be explained by the concepts of attention and automaticity, and may have real-world implications with respect to surgical training and ensuring technical competence.

Attention is the mind's cognitive input sensory mechanism. In a rigid model of attention, only those stimuli attended to, either consciously or unconsciously, will be integrated into memory [2]. In a dual-task or "distracted" situation, attention must be divided between two tasks. It might be assumed that if attention is divided, the invariable result will be a negative effect on the performance of one or both tasks. In fact, depending on the types of tasks and the study design, a distracting stimulus may have a positive, neutral, or negative impact on the performance of a primary task [2]. For example, the ability to find a particular red-lighted number in a display of red numbers was either enhanced or not affected by the presence of distracting green numbers [2]. Conversely, talking on a cell phone simultaneously with driving in a simulator resulted in more accidents and high-risk maneuvers than legal intoxication [6].

Studying the effect of distraction on performance of surgery in a virtual reality laparoscopic simulator (MIST-VR), Goodell et al. [5] found that inexperienced surgeons required more time to complete the simulator tasks when distracted with arithmetic questions. However, in this study of 13 subjects, there was no statistically significant impact on overall simulator score, economy of motion, or errors. Neither the impact of dual-tasking on the performance of the secondary cognitive distracting task itself nor the potential influence that practice or experience may have in negating any distracting effects was described. Our study aimed to examine the influence of surgical experience on a simple surgical skill performed concurrently with a cognitive distraction.

In this study, the sample size was calculated on the basis of the results from a pilot study involving six novices and

**Table 3** Effect of distraction on experienced ($n = 9$) and novice ($n = 31$) surgeon performance (mean ± standard deviation)

| Task | Experienced ($n = 9$) | | | Novice ($n = 31$) | | |
|---|---|---|---|---|---|---|
| | Baseline | Distracted | $p$ Value | Baseline | Distracted | $p$ Value |
| Peg transfer score | 97.7 ± 6 | 96.7 ± 6 | 0.48 | 86.8 ± 12 | 88 ± 8 | 0.38 |
| No. of math questions/min | 9.5 ± 2 | 9 ± 3 | 0.32 | 9 ± 2 | 7.9 ± 2 | <0.001 |
| No. of correct math questions/min | 8.8 ± 3 | 8.4 ± 3 | 0.46 | 7.9 ± 3 | 7.1 ± 2 | 0.02 |
| Percentage of correct math questions | 91.6 ± 7 | 93.4 ± 6 | 0.60 | 85.9 ± 10 | 89 ± 9 | 0.12 |

three experienced surgeons. In the pilot results, the maximum standard deviation for the peg transfer normalized FLS score for the novice group was 8.8. The standard deviation for the experienced surgeons was 5.6. A difference of 10 in the normalized FLS score was considered to be clinically significant, and this was used in the power calculation.

Practically, more novices than experienced subjects are available for study. Because novices show much more variance than experts, we chose an expert:novice ratio of 1:3. To have a power of 0.8 and an alpha of 0.05, the required sample size was calculated to be 11:33. We reached 82% of the target expert sample size and 94% of the target novice sample size.

The subjects were allowed to practice the peg transfer task until their scores showed less than a 10% variation for three consecutive trials. This was done to reduce the effect of the early learning curve for the novice group, in which performance sharply improves with each attempt. Baseline single-task scores for both the peg transfer and computation tasks were recorded. The experienced surgeons scored significantly better on the peg transfer task than the novice surgeons at baseline ($p < 0.01$). Interestingly, because the novice group practiced the surgical task before baseline testing, their baseline scores, although lower than those of the experienced surgeons, were nonetheless in the range expected for “senior” subjects [11]. Despite these baseline scores, the novice and experienced surgeons behaved differently when faced with a concurrent cognitive task.

In the dual-task (distracted) situation, the timing of the peg transfer began when the subject touched the first ring (peg transfer, task 1), after which computation questions (task 2) began as quickly as possible. Neither the novices nor the experienced surgeons showed any decline in performance of the peg transfer task. This result concurs with the previous results of Goodell et al. [5]. However, the novices did have a decline in their performance of the cognitive task, as shown by a decreased number of questions attempted in 1 min, with no change in accuracy. This result is consistent with a significant PRP.

The PRP effect is described as an often large slowing effect observed when people try to perform two speeded tasks close together in time (e.g., beginning within 50 ms of each other). Subjects cannot effectively process or attend to task 2 because their perceptual and central processes are still engaged in task 1 (bottleneck theory) [14]. The effect increases the closer the two stimuli are begun with respect to each other. The responses to the first-presented stimulus often are little affected, whereas the responses to the second stimulus usually are slowed [2]. The PRP effect for a dual-task situation can be significantly decreased and sometimes eliminated if the first task is highly practiced such that performance can become partially or completely automatic (bottleneck bypass) [2].

In this study, the novice surgeons seemed to focus more of their attention on the initially presented surgical skill and did not attend as closely to the cognitive “distractor” presented second, leading to a large PRP effect. The novices attempted significantly fewer questions per minute in the dual-task situation as compared with the single-task baseline ($p < 0.001$), but showed no change in the percentage of correctly answered questions ($p = 0.12$). This suggests that while operating, novice surgeons can make decisions without making more errors, but may require more time to make those decisions. It is possible that this finding is a result of novices “choosing” to attend more to the surgical task because of some perceived greater importance of the peg transfer task (“top-down” theory of attention).

Another explanation may be that the peg transfer performance is preserved because it was the first task presented, and would be expected to show little influence by the PRP effect. Yet another possibility is that peg transfer was a specific type of stimulus that invariably caused the surgical task to be attended to preferentially (“bottom-up” theory) [2].

The surgical task chosen for evaluation in the current study was quite basic. Peg transfer was chosen for its validity and to allow for the participation of a novice surgical group. Whether performance of a more complex surgical task would be “protected” in the face of cognitive distraction or not remains to be investigated.

Automatization in basic surgical skills may allow novice surgeons to integrate multiple stimuli into a complex procedure (reduced-load effects) such that performance is improved even in the face of distractions. In contrast to the novices, it seems that the experienced surgeons had practiced to a level at which the surgical skill became automatic, such that the distracting addition questions did not cause any interference in performance of either task.

The concept of automaticity was intensely studied in the 1970s and 1980s [2, 3, 15]. Automaticity theory states that highly practiced tasks can be performed simultaneously with other tasks without interference. Tasks that are continuous for a time (e.g., surgery) seem to be more conducive to achievement of true automatization than short discrete tasks [16]. Task automatization generally has two features: a lack of voluntary control (i.e., the operation proceeds more or less reflexively given the proper stimulus) and a lack of interference with other ongoing mental processes [2].

Changes associated with automatization that can be measured include a reduction in reaction time, a reduction in load effects, and a reduction in dual-task interference. All these changes need not be present for automatization to exist [2, 3, 15]. In our study, the experienced surgeons had significantly better peg transfer scores at baseline than novice surgeons, showing evidence of decreased reaction time with experience. Furthermore, they also showed no decline in their performance of either the peg transfer or computation tasks in the dual-task situation. In contrast, novice surgeons showed a significant decline in the number of questions answered per minute in the dual-task situation as compared with baseline.

The observed reductions of experienced surgeon performance in both reaction time and dual-task interference suggest that some degree of automatization was achieved by the experienced surgeons, whereas the novices did not achieve automatization. This finding may have significant applications in surgical education and the defining of "real-world" surgical skill competence, in which distractions are commonplace [17, 18, 19].

The results in this study may be relevant clinically because many of the problems from the ward and consultations are initially directed toward the most junior resident surgeons. Recognizing how they respond to cognitive challenges while performing technical maneuvers they are still learning is important in developing strategies for surgical education. Our results, although very preliminary, suggest that while a junior surgeon is learning a procedure, distractions such as urgent questions from the surgical ward and emergency department should be limited, or addressed during times of the operation when the technical challenges are less demanding. As a student surgeon's experience grows, he or she may be increasingly able to answer clinical questions even during a complex surgical procedure because the skill may become automatized. Further studies must be undertaken to define whether a surgical task has any specific features that can be highlighted such that automatization may occur more readily.

A task that truly has become automatized is under involuntary control and can be added to another task without significant decrement in the performance of either task. In this study, its seems the experienced laparoscopic surgeons had achieved a level of automaticity in the peg transfer task that enabled preservation of concurrent cognitive analysis.

These results may address the issue of proficiency-based simulator training. As resident work hours are increasingly limited [20, 21], concerns over surgical proficiency and competency have been raised [22]. Interest in developing simulator-based training and validated tests of proficiency has increased dramatically [8–13].

In current proficiency-based curricula, trainees are required to practice until they achieve a specific performance score [23, 24]. Another putative end point of training is the surgeon's achievement of automaticity, measured as in this study. Further studies involving retention of acquired skill need to be performed to determine whether training to automaticity results in better long-term retention of skill than training simply to achievement of a specific time or score in the simulator.

**Acknowledgments** We thank Alysha J. Catracchia for her assistance in this study. This study was supported by an unrestricted educational grant from Tyco Healthcare Canada.

## References

1. Healey AN, Sevdalis N, Vincent CA (2006) Measuring intraoperative interference from distraction and interruption observed in the operating theatre. Ergonomics 49:589–604
2. Pashler H, Johnston JC, Ruthruff E (2001) Attention and performance. Annu Rev Psychol 52:629–651
3. Van Selst MV, Ruthruff E, Johnston JC (1999) Can practice eliminate the psychological refractory period effect? J Exp Psychol 25:1268–1283
4. Moothy K, Munz Y, Undre S, Darzi A (2004) Objective evaluation of the effect of noise on the performance of a complex laparoscopic task. Surgery 136:25–30
5. Goodell KH, Cao CG, Schwaitzberg SD (2006) Effects of cognitive distraction on performance of laparoscopic surgical tasks. J Laparoendosc Adv Surg Tech 16:94–98
6. Strayer DL, Drews FA, Crouch DJ (2006) A comparison of the cell phone driver and the drunk driver. Human Factors 48:381–391
7. Schneider W, Shriffrin RM (1977) Controlled and automatic human information processing: I. Detection, search, and attention. Psychol Rev 84:1–66
8. Derossis AM, Bothwell J, Sigman HH, Fried GM (1998) The effect of practice on performance in a laparoscopic simulator. Surg Endosc 12:1117–1120
9. Feldman LS, Hagarty SE, Ghitulescu G, Stanbridge D, Fried GM (2004) Relationship between technical skills and subjective in-training evaluations in surgical residents. J Am Coll Surg 198:105–110
10. Peters JH, Fried GM, Swanstrom LL, Soper NJ, Sillin LF, Schirmer B, Hoffman K (2004) Development and validation of a comprehensive program of education and assessment of

the basic fundamentals of laparoscopic surgery. Surgery 135:21–27

11. Fraser SA, Klassen DR, Feldman LS, Ghitulescu GA, Stanbridge D, Fried GM (2003) Evaluating laparoscopic skills: setting the pass/fail score for the MISTELS system. Surg Endosc 17:964–967
12. Peters JH, Fried GM, Swanstrom LL, Soper NJ, Sillin LF, Schirmer B, Hoffman K (2004) Development and validation of a comprehensive program of simulation in laparoscopy. Surg 135:21–27
13. Fried GM, Feldman LS, Vassiliou MC, Fraser SA, Stanbridge D, Ghitulescu G, Andrew CG (2004) Proving the value of simulation in laparoscopic surgery. Ann Surg 240:518–528
14. Welford AT (1967) Single-channel operation in the brain. Acta Psychol 27:5–22
15. Hecht R, Crewther D, Crewther S (2004) Rate of learning and symptotic performance in an automatization task and the relation to reading. Percept Motor Skills 99:1103–1121
16. Hazeltine E, Teague D, Ivry R (2002) Simultaneous dual-task performance reveals parallel response reaction after practice. J Exp Psychol Hum Percept Perform 527–545
17. Shapiro RA, Berland T (1972) Noise in the operating room. N Engl J Med 287:1236–1238
18. Hodge B, Thompson JF (1990) Noise pollution in the operating theatre. Lancet 335:891–894
19. McDonald J, Orlick T, Letts M (1995) Mental readiness in surgeons and its links to performance excellence in surgery. J Ped Orthopedics 15:691–697
20. Council Directive 93/104/EC (1993) Official J Eur Commun L307:18–24
21. Leach DC (2004) A model for GME: shifting from process to outcomes: a progress report from the Accreditation Council for Graduate Medical Education. Med Educ 38:12–14
22. Feanny MA, Scott BG, Mattox KL, Hirshberg A (2005) The impact of the 80-hour work week on resident emergency operative experience. Am J Surg 190:947–949
23. Stefanidis D, Korndorffer JR, Sierra R, Touchard C, Dunne JB, Scott DJ (2005) Skill retention following proficiency-based laparoscopic simulator training. Surgery 138:165–169
24. Seymor NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, Satava RM (2002) Virtual reality training improves operating room performance. Ann Surg 236:458–464