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Abstract

Although endoscopic surgery offers substantial advantages over traditional open surgery in regard to reducing blood loss and to combating infection and pain (Rattner, 1999), endoscopic techniques have been reported to induce high levels of stress in surgeons (Berguer, Smith, & Chung, 2001; Cuschieri, 1995; Vereczkei, Bubb, & Feussner, 2003). Some of that stress is believed to arise because of perceptual-motor distortions associated with the endoscopic interface. Those stress reports, however, are either founded on physicians' informal self-descriptions or upon data gathered during breaks at a medical convention, and they focused upon only one dimension of stress, fatigue. To examine the stress dynamics associated with endoscopic surgery more formally and more completely, the present study simulated the perception-action demands inherent in endoscopic surgery in a controlled laboratory environment, systematically varied perceptual motor distortions, and utilized the Dundee Stress State Questionnaire (Matthews et al., 1999) to provide a multidimensional view of the stress induced by performance in the simulated endoscopic environment.

The results of the study confirmed earlier reports that the endoscopic surgery task is stressful. However, the nature of that stress is far more complex than the earlier investigators had considered. Both beneficial and detrimental reactions are involved and the nature of those reactions is related to the perceptual-motor distortions produced by the endoscopic interface. Participants' efforts to maintain performance under increasing demands by elevating effort were accomplished at a cost of increased stress in the form of increments in feelings of nervousness (tense arousal) and declines in hedonic tone and control and confidence, and the inability to derive a sense of accomplishment in coping

with an unfamiliar situation. Heightened feelings of nervousness and loss of control may be especially critical to surgeons who must assume a heavy mantle of responsibility and exhibit a confident, "command-presence" attitude, and these feelings may be key factors in the fatigue syndrome described in the earlier reports.

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Chapter 1

Introduction

Endoscopic Surgery: Benefits and Costs

The coupling of the operating microscope and video camera has led to a modification of traditional surgery in which the surgical incision is greatly reduced and long, thin instruments replace the surgeon's fingers (Holden, Flach, & Donchin, 1999). The new technique, known as laparoscopic or endoscopic surgery, has the benefit of reducing blood loss, infection, and pain (Rattner, 1999). However, it presents unique cognitive and perception-action problems for the surgeon. Those problems stem from the need to view the operative field through a television monitor that displays images from a small camera placed inside the patient's body. Under these conditions, depth information arising from accommodation and convergence is minimized, stereopsis is eliminated, and the spatial mapping between the camera and the surgical tool is rotated from the normal eye-hand mapping. Those perceptual distortions are known to impede performance efficiency in the endoscopic surgery environment (Eman, Hanna, & Cuschieri, 2002a, 2002b; Reinhardt-Rutland, Annett, & Gifford, 1999). Moreover, the reduction of haptic feedback and the fulcrum effect—having to move the tool handle in the opposite direction of the desired direction of the tip of the tool—also have detrimental influences on performance (Bholat, Haluck, Kutz, Gorman, Krummel, 1999; Gallagher, McClure, McGuigan, Ritchie, & Sheehy, 1998; Ström, Kjellin, Hedman, Wredmark, & Felländer-Tsai, 2004).

In addition to those perceptual-motor problems, reports are available to indicate that surgeons find performing endoscopic surgeries stressful (Berguer, Smith, & Chung,

2001; Cuschieri, 1995; Vereczkei, Bubb, & Feussner, 2003). Since excessive stress is generally known to interfere with human performance (Hockey, 1986; Wickens & Hollands, 2000), this factor could have negative implications for patient safety as well for surgeons' willingness to utilize endoscopic procedures. The challenges posed by endoscopy—the loss of depth information, distortions of the eye-hand mapping, and task-induced stress—are core issues in human factors and experimental psychology (Hancock & Warm, 1987; Palmer, 1999; Welch, 1986; Wickens & Hollands, 2000). Consequently, human factors specialists are in a position to make substantial contributions to understanding the dynamics of endoscopic surgery. Toward that end, the present study was designed to examine further the nature of stress induced by the perception-action conditions of the endoscopic environment and the implications of the loss of depth information and perceptual-motor distortions for task-induced stress. The study made use of a surgical simulator that reduced depth information and introduced a visual-motor rotation while operators completed a task requiring the transporting of foam stars between pegs. Simulators of this sort capture the perception-action demands inherent in endoscopic surgery (Holden et al., 1999) and performance in such simulators has been found to transfer positively to *in vivo* endoscopic performance (Derossis et al., 1998; Hytlander, Liljergen, Rhodin, & Lönroth, 2002).

Stress & Performance

The concept of stress has been used in a number of ways within the human factors community (Alluisi, 1982; Asterita, 1985; Hockey, 1986; Huey & Wickens, 1993). However, most contemporary stress researchers accept a transactional model in which stress is viewed as a relation between the person the environment. According to the

transactional model, stress results when demands of the environment are perceived as exceeding or taxing the individual's resources and endangering his or her well being (Craig & Cooper, 1992; Lazaraus & Folkman, 1984; Matthews, 2001). Although stress has been implicated as a factor in the performance of endoscopic surgery, the studies that have identified this problem are limited in two critical ways. First, the methodologies used in those studies were relatively casual in character. The reports by Cuschieri (1995) and Vereczkei et al. (2003) were founded on physicians' informal self-descriptions and not upon careful empirical measures. Moreover, the sole study utilizing an empirical approach, in which participants rated the stress induced by a simulator task according to a 7-point rating scale (Berguer et al., 2001), is based upon data gathered from surgeons during breaks between sessions at a medical convention. Second, both of those reports featured a one-dimensional approach to stress that essentially identified stress with fatigue. However, fatigue is just one of many symptoms that can result from work stress (Craig & Cooper, 1992), and an approach that focuses solely on fatigue does not adequately address the multidimensional nature of the stress construct. More specifically, a one-dimensional view of stress cannot account for how different environmental stressors can induce differential patterns of cognitive and affective responses across individuals, or within the same individual at different times (Hockey, 1984, 1986; Hockey & Hamilton, 1983). As described by Matthews (2001), stressors affect a variety of qualitatively different mechanisms, operating at a multiplicity of levels. Therefore, a multidimensional characterization of stress is necessary to properly express the nature of stress reactions.

The Dundee Stress State Questionnaire and Endoscopic Surgery

Matthews and his associates (1999, 2002) developed the Dundee Stress State Questionnaire (DSSQ), a well validated instrument for assessing the multidimensional nature of stress expressed through affective, motivational, and cognitive changes. The DSSQ consists of 90 items that yield 10 factor-analytically determined scales: Energetic Arousal (alertness-sluggishness), Tense Arousal (nervousness-relaxation), Hedonic Tone (general feelings of happiness-cheerfulness), Motivation, Self-Focused Attention (self-reflection), Self-Esteem, Concentration, Control and Confidence, Task-Relevant Cognitive Interference (worry about task performance), and Task-Irrelevant Cognitive Interference (worry about personal concerns). The latest versions of the DSSQ afford the facility to score intrinsic motivation and achievement strivings as separate scales, but in this study, the questionnaire was scored to provide a single, general motivation scale. The internal reliability (coefficient Alpha) of those scales ranges between .74 and .89 and the test-retest reliability of the scale over a period of three weeks ranges from .14 to .66 (Matthews et al., 2002). These values are in accord with Zuckerman's (1976) psychometric criteria for state measures, i.e., high internal consistency and low test-retest reliability.

The DSSQ scales were previously subjected to a second-order factor analysis that yielded three higher-order factors, *Worry, Distress,* and *Task-Engagement* (Matthews et al., 1999). The Worry factor is defined by the cognitive dimensions of stress states, encompassing the Task-Related and Task-Irrelevant Cognitive Interference, Self-Focused Attention, and Self-Esteem scales. The Distress factor reflects the importance of unpleasant arousal and low perceived control in states of affective distress. It

encompasses the Tense Arousal, Hedonic Tone, and Confidence and Control scales. Task-Engagement, defined by the Energy, Motivation, and Concentration scales, contrasts enthusiasm and interest with fatigue and apathy. Hence, stress states may be conceptualized using the DSSQ as either ten specifically defined scales or as three broader dimensions that link several discrete stress responses (Szalma et al., 2004). The former approach was adopted in this study.

A number of investigators have shown that the DSSQ scales are differentially sensitive to the demands imposed by a wide variety of tasks including reading, card sorting, vigilance, and simulated automobile driving (Grier et al., 2003; Matthews et al., 1999; Matthews & Desmond, 2002; Matthews, Warm, Dember, Mizoguchi, & Smith, 2001; Matthews et al., 2002; Szalma et al., 2004). In addition, the degree of stress observed using the DSSQ is positively related to the level of cognitive demand imposed by the task (Helton, Warm, Matthews, Corcoran, & Dember, 2002; Matthews et al., 2002; Temple et al., 2000). Temple et al. illustrated the relation between task-induced stress and cognitive demand as measured by the DSSQ in a study that employed a vigilance task, which has been found in several experiments to be quite stressful (Scerbo, 2001; Huey & Wickens, 1993). Observers in the Temple et al. (2000) study performed the vigilance task under conditions in which the signals were easy or difficult to identify. As is the normal procedure with the DSSQ, standardized pre-post vigil change scores for each scale were used to identify the dimensions of task-induced stress. Stress was minimal in the easy condition; the only significant changes observed were post-vigil declines in Self-Focused Attention and Task-Irrelevant Interference and a rise in Self-Esteem, changes that could be considered beneficial rather than detrimental in nature. On the other hand, when

signals were difficult to detect, observers reported a post-vigil increase in Tense Arousal and a post-vigil decline in Hedonic Tone, Motivation, Concentration, and Control and Confidence.

With those findings in mind, the goals for the present study were to use the DSSQ to assess the stress profile associated with endoscopic surgery in a controlled environment and to determine if that profile is related to increasing levels of task demands. Task demand was defined by substituting video imaging for a direct view of the surgical simulator (introducing the basic conditions of endoscopic surgery) and by the degree of disruption of the normal eye-hand mapping resulting from varying the placement of the camera in the endoscopic surgery simulator. Because this was the first study to employ the DSSQ to the problem of endoscopic surgery, no predictions regarding specific DSSQ subscales were made. However, the requirement to control action sequences through TV images and increasing the degree of disruption of eye-hand mapping were generally expected to result in the experience of more aversive stress states (such as negative Hedonic Tone).

Chapter 2

Method

Participants

Fifty-four undergraduates (27 men and 27 women) from the University of Cincinnati participated in the study to fulfill a course requirement. They were between 18 and 31 years of age and were right-handed as indexed by a positive laterality quotient on the Edinburgh Handedness Inventory (Oldfield, 1971). All participants had normal or corrected-to-normal vision, were free of any neuromuscular or skeletal disorders, and had no recent bone fractures or other injuries that might have affected motor performance. None of the participants had prior experience in performing endoscopic surgery simulator tasks.

Experimental Design

Nine male and nine female observers were assigned at random to one of three visuo-motor performance conditions, a control group in which the "surgical field" described below was viewed directly and with no distortion present, and two conditions in which the field was viewed indirectly on a TV screen and the degree of distortion was varied between 0° and 90° in the manner described below.

Apparatus & Materials

The low fidelity endoscopic simulator is illustrated in Figure 1. The simulator was mounted on a table top 61.7 cm above the floor. It consisted of 45 × 30 × 25 cm (front and sides) wooden box which housed a flat "surgical field" consisting of an array of pegs illuminated by a 25 watt lamp located in the rear-left corner of the simulator. The

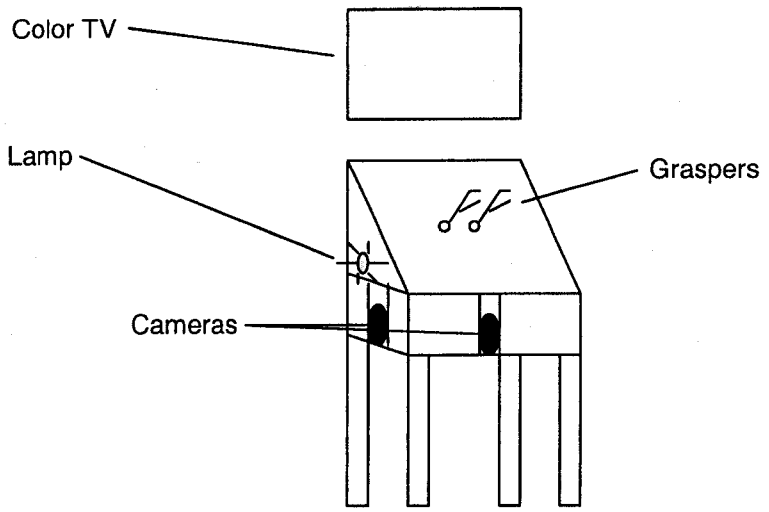

Figure 1. The endoscopic surgery simulator.

field was covered by a transparent Plexiglas screen mounted at a 20° angle between the front of the simulator and its rear wall, which was 43.18 cm in height. Two circular entry ports (0.75 cm in diameter, separated horizontally by 10 cm) were located in the center of the screen. A 5 mm Ethicon endoscopic grasper was placed in each of those ports. As illustrated in Figure 2, the pegboard consisted of right and left columns of three pegs arrayed along a north-south vector separated by 7.7 cm horizontally and by 2.5 cm in depth. The pegs were composed of 2 mm metal nails extending 2 cm above the surface of the field. Five-pointed foam stars (red, orange, yellow, green, or purple in color) weighing 0.23 g served as the transfer items. The stars were 0.04 cm thick and the distance of each wingtip to the center of the star was 1.5 cm. Each star contained a 0.8 cm central opening which permitted it to be impaled on the pegs.

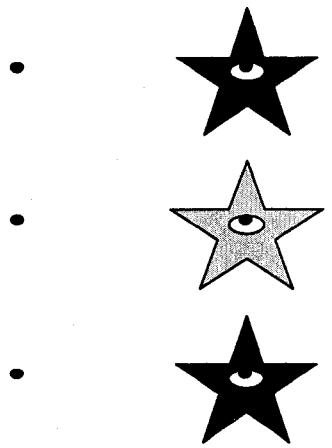

Figure 2. The pegs and foam stars employed in the peg-transfer task.

Two miniature color video cameras were located inside the apparatus. One of the cameras was placed directly in front of the participant; its output defined the 0° distortion condition. The other camera was located 90° clockwise to the participant; its output defined the 90° distortion condition. Both cameras were positioned so that the distance from the camera to the center of the "surgical field" was 17 cm. The cameras portrayed the pegboard on a 20 in. Panasonic color TV screen situated on a stand behind the rear wall of the simulator and located 75 cm in front of the participant at a height of 132 cm above the floor. Participants assigned to either of the two camera conditions (0° and 90° groups) were prevented from viewing the pegboard directly by a removable, opaque sheet of red cardboard that was placed over the Plexiglas screen and was completely congruent with the screen. Testing was conducted individually in a quiet, windowless, room illuminated by four fluorescent ceiling lamps.

Procedure

Upon arrival at the laboratory, participants signed an informed consent form approved by the University of Cincinnati Institutional Review Board and completed a

pretest version of the DSSQ (Matthews et al., 1999) and the Edinburgh Handedness Inventory (Oldfield, 1971). They then took part in a brief familiarization phase in which they were introduced to the graspers and the nature of the task. During this phase, all participants were able to view the pegboard directly. They were asked to start with the right endoscopic gasper and pick up the right star and transfer it in the air to the left grasper, and place the star on the top left peg. Participants performed the same operation with the middle and the bottom star. Once all stars were transferred to the left side of the pegboard participants performed the reverse operation, this time starting with the left grasper and the top left star. They were instructed to transfer the stars as fast as possible without dropping them. If a star was dropped, they were instructed to pick it up with the *grasper from which it was dropped* and to continue with the task. The familiarization phase ended when all of the stars were reversed to the right side of the pegboard. All participants completed the familiarization phase successfully within 3 minutes. During this and the subsequent experimental phase, a group of three different-colored stars was used for each participant. The colors that were selected and their initial position on the right-hand column of pegs were determined at random. Participants were given a two-minute break before the main experimental phase began.

In the main portion of the experiment, only participants assigned to the Control group were able to view the pegboard directly. The TV was not turned on for those participants. Those assigned to the 0° and 90° groups viewed the pegboard through the camera and TV screen. During this phase, participants performed the peg transfer task continuously for 12 minutes with the same instructions as given during the familiarization phase. Within both the familiarization and experimental phases, the experimenter was

seated next to the far right end of the simulator in a position that permitted a clear view of the pegboard and enabled recording of the number of stars transferred and the number of stars dropped. Participants were aware of the experimenter's presence and that their performance was being recorded. Immediately after the experimental phase was completed, participants were administered the posttest version of the DSSQ (Matthews et al., 1999). Copies of the Edinburgh Handedness Inventory, and the pre- and posttest versions of the DSSQ are provided in Appendices A, B, and C, respectively.

Chapter 3

Results

Peg-Transfer Performance

Completed Transfers. Each participant's performance on the peg transfer task was measured in two ways: By the number of transfers completed within the 12 min time limit and by the error rate in accomplishing those transfers, defined as the number of drops divided by the number of transfers. The mean number of completed transfers and the mean error rates for the Control, 0°, and 90° groups are presented in Table 1.

Table 1
Mean Number of Transfers Completed and Mean Error Rates for the Control, 0° and 90° Groups. Values in Parentheses are Standard Errors.

Group	Completed Transfers	Error Rate
Control	107.5 (5.84)	0.06 (0.06)
0°	40.67 (3.32)	0.31 (0.18)
90°	17.17 (2.92)	0.42 (0.51)

It is evident in the table that the number of completed transfers was greatest for the control group followed in order by the 0° and the 90° groups. An analysis of variance (ANOVA) of the data of Table 1 indicated that there was a significant main effect for groups, $F(2, 51) = 122.62$, $p < .01$. Subsequent Tukey tests revealed that all of the groups differed significantly from each other ($p < .05$).

Error Rate. As can be seen in Table 1, performance reflected in the mean error rate paralleled performance reflected in the number of completed transfers: The error rate was lowest in the Control group followed in order by the 0° and 90° groups. An ANOVA of these data also revealed a significant effect for groups, $F(2, 51) = 6.38$, $p < .05$. Subsequent Tukey tests confirmed that the Control group had a significantly lower error rate than either the 0° or 90° groups ($p < .05$). However, unlike the case with the number of completed transfers, the 0° and 90° groups did not differ significantly in their error rates ($p > .05$).

DSSQ

Preliminary analysis revealed that there were no significant differences among the Control, 0°, and 90° groups in regard to any of the pretest DSSQ scales. Accordingly, the effects of the three treatment conditions on the stress state resulting from task performance was assessed by means of standardized pretest/posttest change scores for the scales of the DSSQ according to the formula: *(posttest – pretest) / population standard deviation of the pretest scores.* The pretest normative standard deviation was obtained from Matthews et al. (1999). Change scores are illustrated in Figure 3.

A 3 (groups) × 10 (scales) mixed-design ANOVA (in which the Box correction was used to compensate for violations of the sphericity assumption; Maxwell & Delaney (2004) indicated that there was no significant main effect for Groups ($p > .05$). However, there were significant differences among the Scales, $F(6.29, 320.73) = 25.65$, $p < .01$, and these differences depended upon Groups, $F(12.58, 320.73) = 2.10$, $p < .05$. The nature of the significant Groups × Scales interaction was explored further by using 95% confidence intervals to test each value in Figure 3 against a hypothesis of no change.

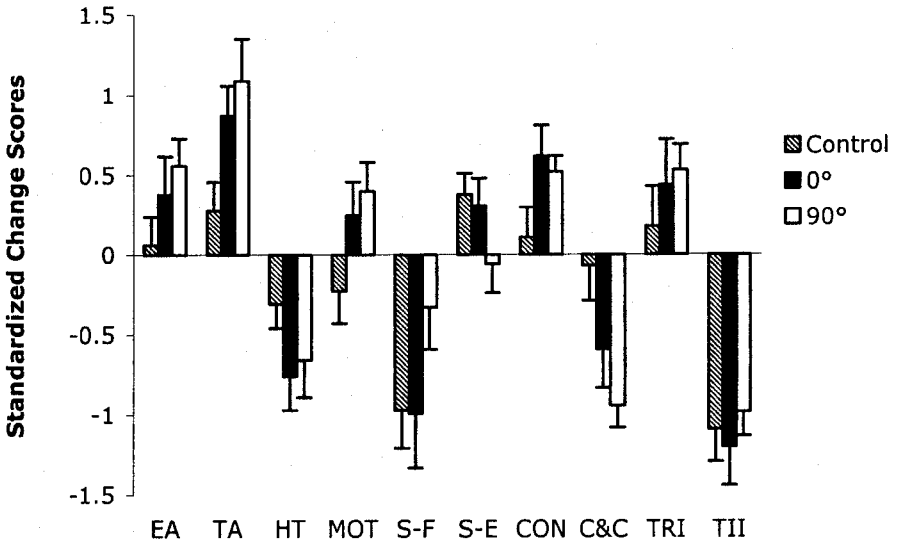

Figure 3. Standardized pre-post change scores for the Control, 0°, and 90° groups for each DSSQ scale. (EA = Energetic Arousal; TA = Tense Arousal; HT = Hedonic Tone; MOT = Motivation; S-F = Self-Focused Attention; S-E = Self-Esteem; CON = Concentration; C&C = Control and Confidence; TRI = Task- Relevant Interference; TII = Task Irrelevant Interference). Error bars are standard errors.

Significant pre-post changes were indicated by any value for which the confidence interval did not encompass zero (Fisher & Belle, 1993). This approach permitted the generation of a change profile for each treatment condition. The change profiles are summarized in Table 2.

Within the Control group, the only significant changes included a posttest increase in Self-Esteem along with evidence of increased task coping strategies as revealed by declines in Self-Focused Attention and Task-Irrelevant Interference. The 0° group also showed evidence of increased task-directed coping strategies as indexed by a significant posttest increase in Concentration accompanied by declines in Self-Focused Attention and Task-Irrelevant Interference. However, those beneficial changes were accompanied by an increase in Tense Arousal and declines in Hedonic Tone and Confidence and Control. Like their cohorts in the other groups, participants in the 90°

group evidenced increased task coping behavior revealed through posttest increases in Energetic Arousal, Concentration, and Motivation, and a decline in Task-Irrelevant Interference. However, those beneficial changes were accompanied by detrimental changes involving increases in Tense Arousal and Task-Relevant Interference along with declines in Hedonic Tone and Confidence and Control.

Table 2
Significant Pre-Post Session Changes for the DSSQ Scales. Arrows Indicate Direction of Change in Posttest Scores Relative to Pretest Measures.

DSSQ Scales	Control	0°	90°
Energetic Arousal			↑
Tense Arousal		↑	↑
Hedonic Tone		↓	↓
Motivation			↑
Self-Focused Attention	↓	↓	
Self-Esteem	↑		
Concentration		↑	↑
Control & Confidence		↓	↓
Task-Relevant Interference			↑
Task-Irrelevant Interference	↓	↓	↓

Chapter 4

Discussion

Performance

The results of this study accord with those of prior investigations indicating that one's ability to carry out action sequences with the graspers featured in endoscopic surgery is rendered more difficult by the need to observe the operative field through TV images that reduce depth information and distort the normal eye-hand mapping (Emam et al., 2002a, 2002b; Reinhardt-Rutland et al., 1999). In the present case in which an endoscopic surgery simulator was employed, participants in the Control group who performed a peg transfer task while viewing the operative field directly transferred significantly more items with a significantly lower error rate than participants who performed the same task while using TV images to observe the operative field.

A potentially important aspect of the present study is the finding that the disruption of performance was directly related to the degree of distortion of the eye-hand mapping with regard to the number of items transferred successfully but not in regard to the error measure. Those outcome differences may provide some insight into the differential roles played by the loss of depth information and the disruption of the eye-hand mapping in the endoscopic environment. Both elements may contribute to problems in the gross transfer of items (i.e., in relatively large-scale directional, movements between rows of pegs) but the minimization of depth information may be of particular importance in the fine-grained control of motor activity require to coordinate the transfer of elements between the graspers and to and from the graspers and pegs.

Stress

Consistent with the reports by Berguer et al. (2001), Cuschieri, (1995) and Vereczkei et al. (2003), the present study demonstrates that the endoscopic environment is conducive to the production of task-induced stress. However, the nature of that stress is far more complex than the earlier investigators had considered—beneficial as well as detrimental reactions are involved and the nature of these reactions is related to task demand.

Participants in all three treatment conditions evidenced reactions aimed at increasing task coping. In the Control group, this was revealed through declines in Task-Irrelevant Interference and Self-Focused Attention. In the 0° group, increased task coping was indicated through the same two changes plus an increase in Concentration. In the 90° group, beneficial changes in Task Irrelevant Interference (posttest decline) and Concentration (posttest increase) were accompanied by increases in Energetic Arousal and Motivation. As described by Humphries and Revelle (1984), increments in energetic arousal can be interpreted as a means of enhancing the availability of cognitive resources needed for coping with a task. Those beneficial reactions were accompanied, however, by several detrimental reactions in the 0° and 90° groups. Both groups exhibited increments in Tense Arousal and declines in Hedonic Tone and Control and Confidence. In addition, the 90° group exhibited an increase in Task-Related Interference. Results such as these reaffirm the notion that stress states require multidimensional description (Hockey, 1984; 1986; Hockey & Hamilton, 1983; Matthews, 2001), and they fit well with Hockey's (1986, 1987) "strain" mode of effortful control in which the struggle to maintain performance under increasing demands by elevating effort is accomplished at a cost of

increased stress. Heightened feelings of nervousness (tense arousal) and loss of control may be especially critical to surgeons who must assume a heavy mantle of responsibility and exhibit a confident, "command presence" attitude. Heightened feelings of nervousness and loss of control may also be elements that contribute substantially to the fatigue syndrome described in the earlier endoscopic surgery studies (Berguer et al., 2001; Cuschieri, 1995; Vereczkei et al., 2003).

The stressful nature of the endoscopic task was further revealed by the finding that participants in the Control group showed an increase in Self-Esteem after completing the experiment while those in the 0° and 90° groups did not. Posttest elevations in Self-Esteem have been reported with the DSSQ in other types of tasks (Alikonis, 2002; Parsons, 2001; Szalma, 2004; Temple et al., 2000) and may reflect a sense of accomplishment in coping with an unfamiliar situation. Recent studies have indicated that positive cognitions can serve to facilitate adjustment to stressful situations by sustaining coping efforts (Folkman & Moskowitz, 2000; Fredrickson, 2001). Clearly, the increased demand placed upon participants by the need to view the operative field through TV images precluded the development of positive cognitions and the adjustment to the demands of the task that is associated with such cognitions. The findings that increments in Self-Esteem were limited to the Control group and that adverse mood changes were found only with the 0° and 90° groups shed further light on the stress dynamics of the endoscopic environment. The findings suggest that task-induced stress in this environment is determined less by the need to use grasping instruments (with the associated fulcrum effect and reduction of haptic feedback) instead of direct manual

manipulation than by the need to guide the use of those instruments by means of TV images that minimize depth information and distort the hand-eye mapping.

It is important to emphasize that the results of this study are based upon the responses of inexperienced undergraduates in an endoscopic surgery simulator and that the experimental conditions could not reproduce the often dramatic life and death stress elements of a medical setting. Consequently, it would be important to replicate these findings with endoscopic surgeons in an actual surgical theater. Nevertheless, since the simulator does capture the perception-action demands inherent in endoscopic surgery (Holden et al., 1999), and since performance in simulators of this sort transfers positively to *in vivo* endoscopic performance (Derossis et al., 1998; Hyltander et al., 2002), the present study does permit some suggestions as to steps that could be taken to enhance endoscopic performance and reduce the task-induced stress caused by the perception-action conditions associated with the endoscopic surgery environment. These include an emphasis on research designed to develop three-dimensional vision systems for use in endoscopic surgery (Tevaearai, Mueller, & von Segesser, 2000; van Bergen, Kunert, Bessell, & Buess, 1998), the development of training programs to aid surgeons in coping with rotational distortions (Jordan, Gallagher, McGuigan, McGlade, & McClure, 2000; cf. Roller, Cohen, Kimball, & Bloomberg, 2001; Welch, Bridgeman, Anand, & Browman, 1993), and the development of design solutions, performance strategies, and training procedures to minimize task-induced stress (Hockey, 1986; Huey & Wickens, 1993; Szalma et al., 2004).

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Appendix A

Edinburgh Handedness Inventory

Please indicate your preference in the use of hands in the following activities by putting a + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent put + in both columns.

Some of the activities require both hands. In these cases the aprt of the the task for which hand preference is wanted is indicated in brackets.

Please try to answer all questions, and only leave a blank if you have no experience at all with the object or task.

		Left	Right
1	Writing		
2	Drawing		
3	Throwing		
4	Scissors		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		
8	Broom (upper hand)		
9	Striking match (match)		
10	Opening box (lid)		
i	Which foot do you prefer to kick with?		
ii	Which eye do you use when using only one eye?		

Appendix A

Pre-DSSQ State Questionnaire

General Instructions. This questionnaire is concerned with your feelings and thoughts at the moment. We would like to build up a detailed picture of your current state of mind, so there are quite a few questions, divided into four sections. Please answer **every** question, even if you find it difficult. Answer, as honestly as you can, what is true of **you**. Please do not choose a reply just because it seems like the 'right thing to say'. Your answers will be kept entirely confidential. Also, be sure to answer according to how you feel **AT THE MOMENT**. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

Before you start, please provide some general information about yourself.

Age..... (years) Sex. M F (Circle one)

Occupation.....

If student, state your course.....

Date today..... Time of day now.....

1. MOOD STATE

First, there is a list of words which describe people's moods or feelings. Please indicate how well each word describes how you feel **AT THE MOMENT**. For each word, circle the answer from 1 to 4 which best describes your mood.

	Definitely	Slightly	Slightly Not	Definitely Not
1. Happy	1	2	3	4
2. Dissatisfied	1	2	3	4
3. Energetic	1	2	3	4
4. Relaxed	1	2	3	4
5. Alert	1	2	3	4
6. Nervous	1	2	3	4
7. Passive	1	2	3	4
8. Cheerful	1	2	3	4
9. Tense	1	2	3	4
10. Jittery	1	2	3	4
11. Sluggish	1	2	3	4
12. Sorry	1	2	3	4
13. Composed	1	2	3	4
14. Depressed	1	2	3	4
15. Restful	1	2	3	4
16. Vigorous	1	2	3	4
17. Anxious	1	2	3	4
18. Satisfied	1	2	3	4
19. Unenterprising	1	2	3	4
20. Sad	1	2	3	4
21. Calm	1	2	3	4
22. Active	1	2	3	4
23. Contented	1	2	3	4
24. Tired	1	2	3	4

25. Impatient	1	2	3	4
26. Annoyed	1	2	3	4
27. Angry	1	2	3	4
28. Irritated	1	2	3	4
29. Grouchy	1	2	3	4

2. MOTIVATION

Please answer some questions about your attitude to the task you are about to do. Rate your agreement with the following statements by circling one of the following answers:

Extremely = 4 Very much = 3 Somewhat = 2 A little bit = 1 Not at all = 0

1. I expect the content of the task will be interesting

   0 1 2 3 4

2. The only reason to do the task is to get an external reward (e.g. payment)

   0 1 2 3 4

3. I would rather spend the time doing the task on something else

   0 1 2 3 4

4. I am concerned about not doing as well as I can

   0 1 2 3 4

5. I want to perform better than most people do

   0 1 2 3 4

6. I will become fed up with the task

   0 1 2 3 4

7. I am eager to do well

   0 1 2 3 4

8. I would be disappointed if I failed to do well on the task

   0 1 2 3 4

9. I am committed to attaining my performance goals

   0 1 2 3 4

10. Doing the task is worthwhile

0 1 2 3 4

11. I expect to find the task boring

0 1 2 3 4

12. I feel apathetic about my performance

0 1 2 3 4

13. I want to succeed on the task

0 1 2 3 4

14. The task will bring out my competitive drives

0 1 2 3 4

15. I am motivated to do the task

0 1 2 3 4

3. THINKING STYLE

In this section, we are concerned with your thoughts about yourself: how your mind is working, how confident you feel, and how well you expect to perform on the task. Below are some statements which may describe your style of thought **RIGHT NOW**. Read each one carefully and indicate how true each statement is of your thoughts **AT THE MOMENT**. To answer, circle one of the following answers:

Extremely = 4 Very much = 3 Somewhat = 2 A little bit = 1 Not at all = 0

1.	I'm trying to figure myself out.	0 1 2 3 4
2.	I'm very aware of myself.	0 1 2 3 4
3.	I'm reflecting about myself.	0 1 2 3 4
4.	I'm daydreaming about myself.	0 1 2 3 4
5.	I'm thinking deeply about myself.	0 1 2 3 4
6.	I'm attending to my inner feelings.	0 1 2 3 4
7.	I'm examining my motives.	0 1 2 3 4
8.	I feel that I'm off somewhere watching myself.	0 1 2 3 4
9.	I feel confident about my abilities.	0 1 2 3 4
10.	I am worried about whether I am regarded as a success or failure.	0 1 2 3 4
11.	I feel self-conscious.	0 1 2 3 4
12.	I feel as smart as others.	0 1 2 3 4
13.	I am worried about what other people think of me.	0 1 2 3 4
14.	I feel confident that I understand things.	0 1 2 3 4
15.	I feel inferior to others at this moment.	0 1 2 3 4

16.	I feel concerned about the impression I am making.	0 1 2 3 4
17.	I feel that I have less scholastic ability right now than others.	0 1 2 3 4
18.	I am worried about looking foolish.	0 1 2 3 4
19.	My attention is directed towards things other than the task.	0 1 2 3 4
20.	I am finding physical sensations such as muscular tension distracting.	0 1 2 3 4
21.	I expect my performance will be impaired by thoughts irrelevant to the task.	0 1 2 3 4
22.	I have too much to think about to be able to concentrate on the task.	0 1 2 3 4
23.	My thinking is generally clear and sharp.	0 1 2 3 4
24.	I will find it hard to maintain my concentration for more than a short time.	0 1 2 3 4
25.	My mind is wandering a great deal.	0 1 2 3 4
26.	My thoughts are confused and difficult to control.	0 1 2 3 4
27.	I expect to perform proficiently on this task.	0 1 2 3 4
28.	Generally, I feel in control of things.	0 1 2 3 4
29.	I can handle any difficulties I encounter	0 1 2 3 4
30.	I consider myself skillful at the task	0 1 2 3 4

4. THINKING CONTENT

This set of questions concerns the kinds of thoughts that go through people's heads at particular times, for example while they are doing some task or activity. Below is a list of thoughts, some of which you might have had recently. Please indicate roughly how often you had each thought **DURING THE LAST TEN MINUTES** or so, by circling a number from the list below.

1= Never 2= Once 3= A few times 4= Often 5= Very often

1.	I thought about how I should work more carefully.	1 2 3 4 5
2.	I thought about how much time I had left.	1 2 3 4 5
3.	I thought about how others have done on this task.	1 2 3 4 5
4.	I thought about the difficulty of the problems.	1 2 3 4 5
5.	I thought about my level of ability.	1 2 3 4 5
6.	I thought about the purpose of the experiment.	1 2 3 4 5
7.	I thought about how I would feel if I were told how I performed.	1 2 3 4 5
8.	I thought about how often I get confused.	1 2 3 4 5
9.	I thought about members of my family.	1 2 3 4 5
10.	I thought about something that made me feel guilty.	1 2 3 4 5
11.	I thought about personal worries.	1 2 3 4 5
12.	I thought about something that made me feel angry.	1 2 3 4 5
13.	I thought about something that happened earlier today.	1 2 3 4 5
14.	I thought about something that happened in the recent past (last few days, but not today).	1 2 3 4 5
15.	I thought about something that happened in the distant past	1 2 3 4 5
16.	I thought about something that might happen in the future.	1 2 3 4 5

Appendix B

Post-DSSQ Questionnaire

General Instructions

This questionnaire is concerned with your feelings and thoughts while you were performing the task you

worked on after the break. We would like to build up a detailed picture of your current state of mind, so there are quite a few questions, divided into four sections. Please answer every question, even if you find it difficult. Answer, as honestly as you can, what is true of you. Please do not choose a reply just because it seems like the 'right thing to say'. Your answers will be kept entirely confidential. Also, be sure to answer according to how you felt **WHILE PERFORMING THE TASK YOU WORKED ON AFTER THE BREAK**. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

1. MOOD STATE

First, there is a list of words which describe people's moods or feelings. Please indicate how well each word describes how you felt **WHILE PERFORMING THE TASK YOU WORKED ON AFTER THE BREAK**. For each word, circle the answer from 1 to 4 which best describes your mood.

	Definitely	Slightly	Slightly Not	Definitely Not
1. Happy	1	2	3	4
2. Dissatisfied	1	2	3	4
3. Energetic	1	2	3	4
4. Relaxed	1	2	3	4
5. Alert	1	2	3	4
6. Nervous	1	2	3	4
7. Passive	1	2	3	4
8. Cheerful	1	2	3	4
9. Tense	1	2	3	4
10. Jittery	1	2	3	4
11. Sluggish	1	2	3	4
12. Sorry	1	2	3	4
13. Composed	1	2	3	4
14. Depressed	1	2	3	4
15. Restful	1	2	3	4
16. Vigorous	1	2	3	4
17. Anxious	1	2	3	4
18. Satisfied	1	2	3	4
19. Unenterprising	1	2	3	4
20. Sad	1	2	3	4
21. Calm	1	2	3	4
22. Active	1	2	3	4

23. Contented	1	2	3	4
24. Tired	1	2	3	4
25. Impatient	1	2	3	4
26. Annoyed	1	2	3	4
27. Angry	1	2	3	4
28. Irritated	1	2	3	4
29. Grouchy	1	2	3	4

2. MOTIVATION AND WORKLOAD

Please answer the following questions about your attitude **to the task you have just worked on after break.** Rate your agreement with the following statements by circling one of the following answers:

Extremely = 4 Very much = 3 Somewhat = 2 A little bit = 1 Not at all = 0

1. The content of the task was interesting

   0 1 2 3 4

2. The only reason to do the task is to get an external reward (e.g. payment)

   0 1 2 3 4

3. I would rather have spent the time doing the task on something else

   0 1 2 3 4

4. I was concerned about not doing as well as I can

   0 1 2 3 4

5. I wanted to perform better than most people do

   0 1 2 3 4

6. I became fed up with the task

   0 1 2 3 4

7. I was eager to do well

   0 1 2 3 4

8. I would be disappointed if I failed to do well on this task

   0 1 2 3 4

9. I was committed to attaining my performance goals

   0 1 2 3 4

10. Doing the task was worthwhile

0 1 2 3 4

11. I found the task boring

0 1 2 3 4

12. I felt apathetic about my performance

0 1 2 3 4

13. I wanted to succeed on the task

0 1 2 3 4

14. The task brought out my competitive drives

0 1 2 3 4

15. I was motivated to do the task

0 1 2 3 4

3. THINKING STYLE

In this section, we are concerned with your thoughts about yourself: how your mind is working, how confident you feel, and how well you believed you performed on the task. Below are some statements which may describe your style of thought during task performance. Read each one carefully and indicate how true each statement was of your thoughts **WHILE PERFORMING THE TASK YOU WORKED ON AFTER THE BREAK**. To answer circle one of the following answers: Extremely = 4 Very much = 3 Somewhat = 2 A little bit = 1 Not at all = 0

1.	I tried to figure myself out.	0 1 2 3 4
2.	I was very aware of myself.	0 1 2 3 4
3.	I reflected about myself.	0 1 2 3 4
4.	I daydreamed about myself.	0 1 2 3 4
5.	I thought deeply about myself.	0 1 2 3 4
6.	I attended to my inner feelings.	0 1 2 3 4
7.	I examined my motives.	0 1 2 3 4
8.	I felt that I was off somewhere watching myself.	0 1 2 3 4
9.	I felt confident about my abilities.	0 1 2 3 4
10.	I was worried about whether I am regarded as a success or failure.	0 1 2 3 4
11.	I felt self-conscious.	0 1 2 3 4
12.	I felt as smart as others.	0 1 2 3 4
13.	I was worried about what other people think of me.	0 1 2 3 4
14.	I felt confident that I understood things.	0 1 2 3 4
15.	I felt inferior to others.	0 1 2 3 4
16.	I felt concerned about the impression I was making.	0 1 2 3 4

17.	I felt that I had less scholastic ability than others.	0 1 2 3 4
18.	I was worried about looking foolish.	0 1 2 3 4
19.	My attention was directed towards things other than the task.	0 1 2 3 4
20.	I found physical sensations such as muscular tension distracting.	0 1 2 3 4
21.	My performance was impaired by thoughts irrelevant to the task.	0 1 2 3 4
22.	I had too much to think about to be able to concentrate on the task.	0 1 2 3 4
23.	My thinking was generally clear and sharp.	0 1 2 3 4
24.	I found it hard to maintain my concentration for more than a short time.	0 1 2 3 4
25.	My mind wandered a great deal.	0 1 2 3 4
26.	My thoughts were confused and difficult to control	0 1 2 3 4
27.	I performed proficiently on this task.	0 1 2 3 4
28.	Generally, I felt in control of things.	0 1 2 3 4
29.	I was able to handle any difficulties I encountered	0 1 2 3 4
30.	I consider myself skillful at the task	0 1 2 3 4

4. THINKING CONTENT

This set of questions concerns the kinds of thoughts that go through people's heads at particular times, for example while they are doing some task or activity. Below is a list of thoughts, some of which you might have had recently. Please indicate roughly how often you had each thought during **THE LAST TEN MINUTES** (while performing the task), by circling a number from the list below.

1= Never 2= Once 3= A few times 4= Often 5= Very often

1.	I thought about how I should work more carefully.	1 2 3 4 5
2.	I thought about how much time I had left.	1 2 3 4 5
3.	I thought about how others have done on this task.	1 2 3 4 5
4.	I thought about the difficulty of the problems.	1 2 3 4 5
5.	I thought about my level of ability.	1 2 3 4 5
6.	I thought about the purpose of the experiment.	1 2 3 4 5
7.	I thought about how I would feel if I were told how I performed.	1 2 3 4 5
8.	I thought about how often I get confused.	1 2 3 4 5
9.	I thought about members of my family.	1 2 3 4 5
10.	I thought about something that made me feel guilty.	1 2 3 4 5
11.	I thought about personal worries.	1 2 3 4 5
12.	I thought about something that made me feel angry.	1 2 3 4 5
13.	I thought about something that happened earlier today.	1 2 3 4 5
14.	I thought about something that happened in the recent past (last few days, but not today).	1 2 3 4 5

15. I thought about something that happened in the distant past 1 2 3 4 5

16. I thought about something that might happen in the future. 1 2 3 4 5