Title: Exploring Personality Dimensions that Influence Practice and Performance of a Simulated Laparoscopic Task in the OSCE

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Abstract

Background

Surgical educators have encouraged the investigation of individual differences in aptitude and personality in surgical performance. An individual personality difference that has been shown to influence laparoscopic performance under time pressure is movement specific reinvestment. Movement specific reinvestment has two dimensions, movement self-consciousness (i.e., the propensity to consciously monitor movements) and conscious motor processing (i.e., the propensity to consciously control movements), which have been shown to differentially influence laparoscopic performance in practice, but have yet to be investigated in the context of psychological stress (e.g., the objective structured clinical examination, OSCE).

Objective

This study investigated the role of individual differences in propensity for movement self-consciousness and conscious motor processing in practice of a fundamental laparoscopic skill and in laparoscopic performance during the OSCE. Furthermore, this study examined whether individual differences during practice of a fundamental laparoscopic skill were predictive of laparoscopic performance during the OSCE.

Methods

Seventy seven final year undergraduate medical students completed the Movement Specific Reinvestment Scale (MSRS), an assessment tool that quantifies the propensity for movement self-consciousness and conscious motor processing. Participants were trained to proficiency on a fundamental laparoscopic skill. The number of trials to reach proficiency was measured and completion times were recorded during early-practice, later-practice and during the OSCE.

Results

There was a trend for conscious motor processing to be negatively associated with the number of trials to reach proficiency ($p = .064$). A higher propensity for conscious motor processing was associated with fewer trials to reach proficiency ($\beta = -0.70$, $p = .023$). Conscious motor processing and movement self-consciousness did not significantly predict completion times in the OSCE (p's $> .05$). Completion times in early- ($\beta = 0.05$, $p = .016$) and later-practice ($\beta = 0.47$, $p < .001$), and number of trials to reach proficiency ($\beta = 0.23$, $p = .003$), significantly predicted completion times in the OSCE.

Conclusion

It appears that a higher propensity for conscious motor processing predicts faster rates of learning of a fundamental laparoscopic skill. Furthermore, laparoscopic performance during practice is indicative of laparoscopic performance in the challenging conditions of the OSCE. The lack of association between the two dimensions of movement specific reinvestment and performance during the OSCE is explained using the Theory of Reinvestment as a framework. Overall, consideration of personality differences and individual differences in ability during practice could help inform the development of individualized surgical training programs.

ACGME competencies: Practice based learning and improvement

Keywords: laparoscopic training, movement specific reinvestment, OSCE, individual differences, movement self-consciousness, conscious motor processing

Introduction

Since its advent in 1975, [1] the objective structured clinical examination (OSCE) has been shown to be a valid and reliable [2] tool that assesses technical and non-technical aspects of clinical competence. The OSCE has been integrated into undergraduate medical education [3] and can help screen surgical potential at an early stage, which has obvious safety and financial implications. [4] Recently, surgical educators have discussed the importance of identifying appropriate individual differences in aptitude and personality that can also be used to determine surgical potential. [5] Notably, Arora and colleagues [6,7] have encouraged research on personality differences in responding to stress; a factor that surgeons [8] and surgical trainees (e.g., OSCE) [9,10,11] alike, encounter on a regular basis.

Previous research has identified individual differences in aptitudes that predict performance of laparoscopic technical skills [12-14] and individual differences in personality that predict performance of non-technical skills components of the OSCE. [15] However, there is limited research that has specifically identified individual differences in personality that might impact technical skills performance in stressful situations like the OSCE.

One particular personality characteristic that has been shown to impact performance of a fundamental laparoscopic skill under time pressure is movement specific reinvestment; the propensity to consciously monitor and control one's movements. [16] The Theory of Reinvestment [17] suggests that consciously intervening in skill execution can disrupt normally automatic motor processes, causing the smooth, automated movements of skilled performers to reflect the erratic, jerky movements of their less skilled counterparts. In support of the Theory of Reinvestment, Malhotra, Poolton, Wilson, Ngo and Masters [16] found that a high propensity, as opposed to a low propensity, for movement specific reinvestment was associated with an inability to cope with time pressure demands.

Movement specific reinvestment has two dependent dimensions; movement self-consciousness and conscious motor processing, which differentially influence performance. Specifically, Malhotra, Poolton, Wilson, Fan and Masters [18] revealed that movement self-consciousness (i.e., conscious monitoring of movements) influenced performance of a fundamental laparoscopic skill early and later in practice, with a higher propensity associated with slower completion times. However, when the task demands were raised (cross-handed laparoscopy), [19] conscious motor processing (i.e., conscious control of movements) influenced performance, with a higher propensity associated with slower completion times. The findings of Malhotra et al. [18] imply that the two dimensions differentially influence performance under different circumstances, but their influence in other demanding circumstances, such as psychological stress, have yet to be examined. Specifically, demanding circumstances may bring about a transition from simply monitoring movements to consciously controlling them, suggesting that conscious motor processing should play a more distinct role in performance under psychological stress.

The aims of this study were three-fold. First, we sought to examine the differential influence of the two dimensions of movement specific reinvestment on performance during early-practice and later-practice (completion time, errors) and on the number of trials to reach proficiency. In line with the findings of Malhotra et al., [18] movement self-consciousness was expected to be associated with slower performance early and later in practice but it was unclear which of the two dimensions would predict the amount of practice required to reach proficiency. Second, the study also explored how the two dimensions of movement specific reinvestment influenced performance of laparoscopic technical skills under psychological stress (i.e., during completion of the OSCE). Psychological stress associated with the OSCE was expected to increase the performance demands, so conscious motor processing was expected to be associated with slower completion times. The third aim of this study was to investigate whether individual differences during practice of a fundamental laparoscopic skill predicted laparoscopic performance during the OSCE.

Methods

Participants

One hundred and five final year (MBBS) medical students (age range, M = 24.25, SD = 2.04) with no prior experience of laparoscopy volunteered to participate in the study. Twenty-eight participants were excluded from the study as a consequence of failure to achieve proficiency on the laparoscopic task (n = 6), absence from the second session (later-practice, n = 9) or non-completion of the MSRS (n = 13). Subsequently, 77 participants were included in the study. The study was approved by the Institutional Review Board and informed consent was obtained from all participants.

Study Design

The study assessed performance of a fundamental laparoscopic skill during practice (see Figure 1a) and during the OSCE (see Figure 1b). Participants were invited to attend practice sessions in pairs in the month prior to their OSCE examination. Participants signed up for practice sessions online and practice was carried out in a simulated operating theatre (OT). Before commencement of the study, participants completed the Movement Specific Reinvestment Scale (MSRS).[20] The MSRS is comprised of two subscales of five items each, representing movement self-consciousness (MS-C) and conscious motor processing (CMP). The

MS-C subscale includes items such as "I am concerned about my style of moving" and the CMP subscale includes items such as "I am always trying to think about my movements when I carry them out". Participants respond to the items on a Likert Scale ranging from (1) strongly disagree to (6) strongly agree. Scores range from 5-30 points for each subscale. Scores on the subscales of the MSRS represent participants' predisposition for MS-C and CMP with higher scores corresponding to a greater propensity for either MS-C or CMP.

After completing the MSRS, participants were shown an introductory video to familiarize them with the laparoscopic task. The Fundamentals of Laparoscopic Surgery (FLS) peg transfer task [21] required participants to use laparoscopic graspers to pick up, transfer and place six plastic objects one at a time from one side of the peg-board to the other and back again. The first half of the trial involved transfer from the laparoscopic grasper held by the non- dominant hand to the dominant hand and the second half of the trial involved the reverse. Trial completion time and errors (number of times pegs were dropped) were the main performance measures. Completion time began when the first peg was grasped and stopped when the last peg was released. Practice was considered complete when participants attained the criterion level of proficiency, completion of two consecutive trials within 54 s (with no pegs dropped) followed by completion of a further 10 trials at criterion level. [22]

Participants were invited back for a second session at least 24 hours after attaining proficiency. After a warm up session, in which they were required to complete two consecutive trials at criterion level, participants were asked to perform two trials (later-practice trials) as they had done during the previous practice session.

A third session was conducted during the OSCE, using a laparoscopic skills station that was one of 16 OSCE stations. The OSCE was conducted during the summative assessment of participants' clerkship. The setup of the station was slightly different from practice sessions.[1] Participants were allowed 6 min at each station with a bell indicating the end of the session. Participants attempted to complete three peg transfer trials at the laparoscopic station.

****Figure 1 near here****

Statistical Analysis

Trial completion time and errors in the first two and the last two practice trials were recorded as measures of performance during early-practice and later-practice, respectively. 18 The number of trials to reach proficiency was also recorded. Fastest completion time during the OSCE was entered into the analysis due to some participants only completing a single trial at the OSCE laparoscopic station. Given that the number of drops recorded during early-practice (*M* = 0.27, *SD* = 0.68), later-practice (*M* = 0.13, *SD* = 0.29) and the OSCE (*M* = 0.11, *SD* = 0.29) were minimal, this measure was excluded from all further analysis. Since some of the variables were not normally distributed, Spearman's rho correlations were carried out to assess the strength of associations between the two MSRS sub-scales (MS-C & CMP) and the measures of performance during the practice session (number of trials to proficiency and completion time during early- and later-practice) and in the OSCE (fastest completion time)

In the first instance, our three aims were addressed by assessing associations between i) the two MSRS subscales and performance during the practice session; ii) the two MSRS

[1] The testing session was not carried out in a simulated OT environment and participants were tested individually rather than in pairs. The laparoscopic monitor was smaller and placed at a lower height than in training and the height of the laparoscopic box was not adjustable (during training the height of the operating bed could be adjusted).

subscales and performance in the OSCE; and iii) performance during the practice sessions and performance in the OSCE. Statistical significance levels were set at $p < .05$.

Significant correlations between the MS-C and CMP dimensions of movement specific reinvestment and performance measures were followed up by multiple regressions to assess the unique influence of MS-C and CMP on performance during practice and in the OSCE. The two dimensions of movement specific reinvestment were not too highly correlated ($r = .518$); a calculation of the collinearity diagnostics revealed that the variance inflation and tolerance statistics were acceptable. The correlations between performance measures during practice and the OSCE were followed up by simple regressions. A visual examination of standard scatterplots revealed that linearity and homoscedacity assumptions were met. Cook's distance was calculated to test the data for any outliers, and none of the cases were found to unduly influence the parameters of the model.[2] The Durbin-Watson Statistics for all models was within an acceptable range (> 1 and < 3), indicating that the independence of errors assumption was met.

Results

Table 1 presents the descriptive statistics for all variables and the Spearman's rho correlation coefficients between variables.

[2] Cook's distance is a measure of the influence of a particular case on the overall regression model. Cases with Cook's distance >1 might represent outliers in the model.[23]

Table 1
Descriptive statistics for all variables and Spearman's rho correlation coefficients of the relationship between variables

	Median	IQR	MS-C	CMP	Comp time (E-P)	Comp time (L-P)	No. trials to prof
MS-C	18	13.5 - 22.0	-				
CMP	20	18.0 - 23.0	.518**	-			
Comp time (E-P)	107	88.3 - 128.8	-.219	-.210	-		
Comp time (L-P)	46	41.0 - 49.8	-.106	-.174	.399**	-	
No. trials to prof	26	20.5 - 31.5	-.162	-.229*	.692**	.228*	-
Comp time (OSCE)	46	43.0 - 52.0	-.164	-.237*	.470***	.443***	.381**

***$p < .001$, **$p < .01$, * $p < .05$
IQR- Interquartile Range
MS-C = movement self-consciousness; CMP = conscious motor processing
Comp time (E-P) = completion time (early-practice); Comp time (L-P) = completion time (later-practice)
No. trials to prof = number of trials to reach proficiency; Comp time (OSCE) = completion time (OSCE laparoscopic task)

MS-C and CMP scores were both negatively correlated with completion time in early-practice, but both effects only approached statistical significance (p = .056 & p = .067, respectively). Neither factor was significantly correlated with completion times in later-practice (p's > .129). CMP was significantly negatively correlated with the number of trials to proficiency (p = .045) but MS-C was not (p = .159) (see Table 1).

A multiple regression was carried out to assess the unique influence of MS-C and CMP on the number of trials to reach proficiency (see Table 2a). The overall model approached significance, F(2,74) = 2.85, p =.064, explaining 7.2 % of the variance. CMP significantly contributed to the model uniquely explaining 7 % of the variance in trials to proficiency, t(74)= -2.33, p = .023. Higher scores on the CMP subscale were associated with fewer trials to reach proficiency.

CMP was significantly negatively correlated with completion time in the OSCE (p = .038) but MS-C was not (p = .154) (see Table 1). The subsequent multiple regression analysis resulted in a non-significant overall model for predicting completion time in the OSCE from MS-C and CMP (*p* = .176) (see Table 2b).

Table 2
Multiple regressions predicting the number of trials to reach proficiency and completion time in the OSCE from MS-C and CMP

		Variables	*B*	*t*	sr^2_{unique}	
a.	No. trials to prof	MS-C	0.20	0.82	.01	
		CMP	-0.70	-2.33*	.07	
			Intercept = 38.62			
						$R^2 = .072$
						$R^2_{adj} = .046$
						R = .267
b.	Comp time (OSCE)	MS-C	-0.09	-0.52	.00	
		CMP	-0.26	-1.25	.02	
			Intercept = 54.04			
						$R^2 = .046$
						$R^2_{adj} = .020$
						R = .214

***$p < .001$, **$p < .01$, * $p < .05$
MS-C, movement self-consciousness; CMP, conscious motor processing
No. trials to prof = number of trials to reach proficiency; Comp time (OSCE) = completion time (OSCE laparoscopic task)

As shown in Table 1, completion times in the OSCE were positively correlated with completion times in early-practice ($p < .001$) and later-practice ($p < .001$), as well as with the number of trials to reach proficiency ($p = .001$). The simple regression analysis reported in Table 3 shows that completion time in the OSCE was significantly predicted by completion time in early-practice, $F(1,75) = 6.11$, $p = .016$, explaining 7.5% of the variance, $t(75) = 2.47$, $p = .016$ (see Table 3a), completion time in later-practice, $F(1, 75) = 19.57$, $p < .001$, explaining 20.7% of the variance, $t(75) = 4.42$, $p < .001$ (see Table 3b), and also the number of trials to reach proficiency, $F(1, 75) = 9.77$, $p = .003$, explaining 11.5% of the variance, $t(75) = 3.13$, $p = .003$ (see Table 3c). Overall, slower completion times in early-practice and later-practice as well as a greater number of trials to reach proficiency predicted slower completion times in the OSCE.

Discussion

Surgical educators have emphasized the need to identify individual differences in personality and aptitudes in order to improve the efficiency and effectiveness of surgical training. [5,7] Movement specific reinvestment is a personality characteristic that has been shown to impact laparoscopic performance during practice 18, as well as under time pressure. 16 We investigated whether the influence of individual differences in movement specific reinvestment, on laparoscopic performance during practice, extends to performance in a clinical examination (i.e., OSCE). Furthermore, we investigated whether individual differences in early markers of task aptitude predicted performance in the OSCE.

Faster completion times on the laparoscopic task early in practice tended (findings approached significance) to be associated with a higher propensity for movement self-consciousness (i.e., conscious monitoring of movements). This is not consistent with Malhotra et al. [18] who found that a higher propensity for movement self-consciousness was associated with slower rather than faster completion times. The discrepancy between the findings may be attributable to the different practice setups, as in the current study participants practiced in pairs rather than individually. It is possible that the presence of a peer might have caused participants with a higher propensity for movement self-consciousness to become concerned about making a good impression3 by meeting task demands. 24,25 More specifically, a high propensity for movement self-consciousness might better attune individuals to their movements (i.e., more focused) 26 and might enable them to utilize feedback (e.g., visual, tactile) to gauge the match (or mismatch) between current and desired states of performance. 27 Regardless of the explanation for the findings, it appears that training highly movement self-conscious individuals (in particular, medical students), in

[3] Item 10 of the MSRS; "I am concerned about what people think about me when I am moving", lends support to this proposition.

the presence of significant others might help attenuate the negative effects of movement self-consciousness on performance early in practice.

Conscious motor processing tended (findings approached significance) to be associated with faster completion times early in practice which is incongruent with the findings of Malhotra et al., 18 who did not find any association between this dimension of movement specific reinvestment and performance early in practice. Again, this inconsistency between findings could potentially be attributable to the paired practice setup used in the current study. The presence of a peer might have raised task demands and encouraged participants to consciously control movements (i.e., conscious motor processing) in order to ensure success. Later in practice, however, conscious motor processing was not associated with performance, which is not surprising given that skill execution at this later stage should not require conscious control of motor processes.

With regard to number of trials to reach proficiency, a higher propensity for conscious motor processing was associated with fewer trials to reach proficiency, suggesting that an inclination to consciously control movements might have facilitated the search for motor solutions during practice, thereby speeding up the journey to proficiency. Although, conscious involvement in the control of movement has previously been shown to negatively influence performance during practice, [28] there is evidence to suggest that in certain instances it might be beneficial.[29,30] A cognitively efficient way in which to increase conscious control of movements without incurring adverse effects could be to use heuristics [31] or analogy learning paradigms. [32] An analogy is a 'biomechanical metaphor' that conveys knowledge about the movement in a condensed form (i.e., with minimal rules). For instance, surgical trainees taught to perform a blunt dissection of tissue might be instructed to 'split it like a two-layered business card': "start a split at one corner by bending it to and fro and then pull the layers apart". [31]

This study also examined the roles of the two dimensions of movement specific reinvestment in the challenging OSCE context. It has been postulated that more demanding tasks (e.g., cross-handed laparoscopy) cause a transition from conscious monitoring to control. [18] Following this line of reasoning, we expected the demanding circumstances of the OSCE to evoke conscious motor processing (i.e., conscious control of movements). However, this was not the case. Conscious motor processing was not associated with completion times during the OSCE. One possible explanation for this finding is that the OSCE was not demanding enough to elicit conscious motor processes. Although, the OSCE has been shown to raise levels of perceived anxiety, 9,10,11 the demands of other situations like cross-handed laparoscopy might be more likely to cause individuals to adopt conscious control of their movements. Multi-dimensional workload measures like the SURG-TLX 33 can be used to help quantify the psychological and physical demands of a procedure. Potentially, such measures can be used to identify those surgical stressors that are most likely to evoke conscious motor processing.

Lastly, the findings of the current study revealed that, overall, individual differences in ability predicted laparoscopic performance in the OSCE. Perhaps not surprisingly, participants who required fewer trials to reach proficiency and who performed faster in early-practice and later-practice also performed faster on the laparoscopic skills component of the OSCE. Our results suggest that performance in practice, as early as the first two trials, can potentially help identify good from bad performers. These findings are in line with previous studies that have found that superior visual-spatial, depth perception and psychomotor abilities positively predicted simulated laparoscopic performance. [12-14] The current surgical climate encourages advancement on the basis of competence and the findings of this study along with previous studies imply that measuring aptitudes on more general tasks as well as specific tasks can help identify competent individuals during the earlier stages of practice.

One of the limitations of this study was that no manipulation checks were used for measuring stress, making it difficult to ascertain whether the absence of a negative effect of conscious motor processing on performance in the OSCE was due to a lack of psychological stress. This seems unlikely, however, given that students have previously been shown to experience raised levels of stress during the OSCE. [9,10,11] Another limitation of this study was that apart from the efficiency (completion time) and accuracy (errors) performance measures used to assess the manual skills components of the fundamentals of laparoscopic surgery (FLS) no other precise measures of movement efficiency were included. Future studies should utilize more sophisticated hand motion analysis systems to unravel the underlying mechanisms by which individual differences in personality influence performance. For example, Uemura et al. [34] have developed a hand motion analysis system that goes beyond measuring individual differences in technical competence by measuring "the grace with which competency is performed" (p. 13). Such a tool might be particularly sensitive to underlying mechanisms associated with movement self-consciousness and conscious motor processing.

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Figure Legends

Figure 1. Experimental setup during (a) laparoscopic training and (b) the OSCE.

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