Use of a Novel Measure of Nontechnical Skills in Surgical Trainees: Is There an Association With Technical Skills Performance?

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OBJECTIVE: To investigate whether scores on a psychological measure of concentration and interpersonal characteristics, The Attentional and Interpersonal Style Inventory (TAIS), are associated with performance of surgical skills.

DESIGN: Postgraduate surgical trainees completed an operative surgical skills assessment in the simulation laboratory and the psychological measure (TAIS). The surgical skills assessment consisted of 6 tasks (3 per trainee): laceration suturing; lipoma excision; incision and closure of a laparotomy wound; bowel anastomosis; saphenofemoral junction ligation and basic laparoscopic skills. The association between operative surgical skill performance and TAIS factors was investigated.

SETTING: The TAIS assessments and surgical skills assessments were conducted at the National Surgical Training Centre at the Royal College of Surgeons in Ireland (RCSI).

PARTICIPANTS: One hundred and two surgical trainees in years one and two (PGY 2-3 equivalent) participated in the study.

RESULTS: Performance on 2 of the 6 tasks assessed (bowel anastomosis and lipoma excision) were positively associated with multiple TAIS factors (energy, confidence, competitiveness, extroversion, self-criticism and performing under pressure). Another factor, focus over time, was significantly associated with scores on the lipoma excision task.

CONCLUSIONS: Trainees with high levels of energy, confidence, competitiveness, extroversion, and focus over time and low levels of self-criticism demonstrated better performance on specific technical skills tasks. (J Surg Ed 76:519–528. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: surgical training, personality, performance, technical skills, nontechnical skills, surgical skills assessment

COMPETENCIES: Practice-Based Learning and Improvement, Interpersonal and Communication Skills

INTRODUCTION

Interpersonal skills have long been recognized as important factors which impact safety in surgical practice.[1-4] On the positive side, certain personality characteristics such as extroversion and conscientiousness have been shown to be reliable predictors of performance in undergraduate and postgraduate medical training.[5] However, the negative effects of disruptive behavior in the operating room on teamwork and communications have also been described and many surgeons believe these factors are responsible for the majority of errors [6,7].

Assessment and training in nontechnical skills have recently been highlighted as a necessary component of surgical training.[8,9] Nontechnical skills have repeatedly been shown to be one of the main contributing factors in medical error[10,12,13] and training in this area addresses the recommendations of reports on medical error which in the US concluded that medical errors result in up to 98,000 deaths per year.[10] In the UK, it has been estimated that up to 10% of hospital inpatients suffer adverse events and that 50% of these are avoidable.[11]

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The operating theatre is a highly pressurized environment and is one of the top three areas in the hospital setting associated with the greatest risk of medical error.[14-16] It is an environment where the surgeon must face cognitively and technically challenging tasks in a limited period of time. Alongside this, the surgeon is burdened with the knowledge that the impact of any error may have serious consequences.

Stress is defined as the interaction between three elements: perceived demand, perceived ability to cope and the perception of the importance of being able to cope with the demand.[17, 18] Previous studies have demonstrated that poor stress coping ability correlates with poor surgical performance.[5, 19, 20] Arousal theory suggests that some stress can add to and enhance performance, however as the level of stress increases, performance can be impaired.[21] This effect has been well documented in the aviation industry.[22, 23] Some of the negative effects of stress include impairment of attention, vigilance, memory, judgment and decision-making.[24-27]

It is recognized that certain personality traits among doctors are related to outcomes such as stress and burnout.[1, 28-30] Personality testing is widely used for employee selection[31-33] and interest in the use of personality assessment for the selection of surgeons has been expressed in the literature.[34-36] To date however the relationship between the personal attributes of surgeons in training and surgical expertise has not been reported. In particular no psychometric test that specifically evaluates an individual's ability to perform under pressure has been examined in relation to surgical performance.

The Attentional and Interpersonal Style Inventory (TAIS) is an easily administered self-report instrument designed to measure those interpersonal characteristics and concentration skills that are the building blocks of performance.[37,39] It is used to identify the types of situations and conditions under which an individual is more or less likely to perform at their potential. This measure has been used for both selection and development purposes within the sporting world and within the work environment. It has been used to assess performance in elite athletes in swimming, gymnastics and figure skating, in military units and in business settings.[38] We feel that this instrument measures interpersonal abilities that are highly applicable to surgical performance and so we sought to establish if such an association could be identified.

MATERIALS AND METHODS

As the published literature in this area is limited, we chose an explorative study design with the aim of evaluating whether scores on the TAIS are associated with scores on assessments of surgical technical skills performance. In order to minimize the possibility of false positive errors which can result from an explorative study such as this, we have reduced the number of variables for the purposes of comparison as described below.

Recruitment of Participants

There were 128 participants initially recruited to this study, all year-one and year-two surgical trainees (PGY 2-3 equivalent). Each of these trainees on our program is required to take part in a technical skills assessment prior to progression to the next year of training. Completion of the TAIS was voluntary and was conducted at the end of the training year.

The trainees gave written informed consent allowing all data collected to be analyzed. All nontechnical ability data collected was stored in an anonymous format and this was outlined in the consent process.

The assessments were performed at the National Surgical Training Centre, Royal College of Surgeons in Ireland (RCSI), 121 St. Stephen's Green, Dublin 2.

Ethical approval for the study was awarded by the Research Ethics Committee of the RCSI.

The Attentional and Interpersonal Style Inventory

The TAIS consists of 144 items distributed across twenty scales. It measures 14 different personal and interpersonal behavioral attributes and 6 different concentration skills. These 20 scales can be organized in groups to form nine 'factors' which describe certain recognizable traits in individuals (Table 1). The test-retest reliability of the TAIS has been reported as $r = 0.83$.[39] The content, construct, and predictive validity have also been described.[40]

The TAIS was administered in a paper based format. Each item used a 5 point Likert style scale and response options were 'Never', 'Rarely', 'Sometimes', 'Frequently' or 'Always'. The candidates were informed that the TAIS, similar to most psychological assessments, have measures in place to control for any individual who seeks to present an overly positive or negative impression of themselves. The TAIS questionnaires were completed on paper and the scores were then entered manually into the website of the company that holds the license for this psychometric assessment, multi-health system (MHS) assessments (https://www.mhs.com)[63]. All the data was anonymized and entered into a database for analysis. MHS scored each individual assessment and provided a dataset containing percentile scores for each individual. Percentile scores were derived by comparing the respondents' raw scores to those of previously established norms of a comparable demographic group. These norms were established during the development of the TAIS instrument.

TABLE 1. Description of TAIS Scales and Factors

TAIS Scales (No. 20)	Factor	Scales Measured for This Factor	High Scores	Low Scores
1. Awareness	**Confidence**	1. Awareness	Positive attitude	Negative attitude
2. Analytical/Conceptual		2. Analytical/conceptual		
3. Information processing		3. Information processing		
4. Control		4. Control		
5. Self-confidence		5. Self-confidence		
6. Extroversion		6. Extroversion		
7. Expression of ideas/intellectually competitive		7. Expression of ideas/ intellectually competitive		
8. Expression of support and affection		8. Expression of support and affection		
9. Physical competitiveness	**Energy**	1. Awareness	Versatile, can manage many challenges at once	Does not like change
10. Introversion		2. Analytical/conceptual		
11. Expression of ideas/intellectually competitive		3. Information processing		
12. Expression of criticism and anger	**Competitiveness**	4. Control	Drive to be in control and to take the lead	Anxious when expected to lead
13. Internal distractibility		5. Self-confidence		
14. Reduced flexibility		9. Physical competitiveness		
15. Decision-making style	**Extroversion**	6. Extroversion	Socially outgoing	Prefers to work in isolation
16. Action-focused		10. Introversion		
17. External distractibility		8. Expression of support and affection		
18. Orientation toward rules and risk	**Critical**	4. Control	Argumentative	Intimidated
19. Focus over time		11. Expression of ideas/ intellectually competitive		
20. Performance under pressure		12. Expression of criticism and anger		
	Anxiety	13. Internal distractibility	Perfectionist	Risk-taker
		14. Reduced flexibility		
		15. Decision-making style		
	Distractibility	16. Action-focused	Inability to stay focused	Control over emotions and concentration
		17. External distractibility		
		13. Internal distractibility		
		18. Orientation toward rules and risk		
		12. Expression of criticism and anger		
	Focus over time	19. Focus over time	Good ability to establish goals and set priorities	Low ability
	Performance under pressure	20. Performance under pressure	Seeks out high pressure situations	Avoids high pressure situations

Technical Skills Assessments

Trainees completed a compulsory assessment of their operative surgical skills delivered in an objective structured clinical examination (OSCE) format. The stations were as follows; Year One: Laceration Suturing, Lipoma Excision, and Incision and Closure of a Laparotomy Wound; Year-Two: Bowel Anastomosis, Saphenofemoral Junction Ligation, and Basic Laparoscopic Skills. The bench models were sourced from Limbs and Things (Bristol, UK) and the ProMIS simulator (Haptica, Dublin, Ireland) was used for assessing basic laparoscopic skill. The tasks assessed were based on the technical skills taught during the trainees' operative skills classes during the academic year. The trainees were examined by consultant surgeons in clinical practice who had prior experience of teaching and assessing these technical skills in the simulation laboratory. All assessors underwent examiner training and calibration, specific to this assessment process and tools. A procedure-specific checklist in combination with the Objective Structured Assessment of Technical Skills (OSATS) taxonomy was used by the examiners to score each candidate.[41, 42] All locally developed checklists were evaluated for acceptable levels of interrater reliability prior to use.

In order to estimate the difficulty of each task, a panel of nine consultant surgeons was asked to independently rank the difficulty of the tasks for each year of trainee. These experts were not involved in the assessment of the trainees for this study; however, they had prior experience of the assessment process and scoring mechanism. They had previously undergone examiner training and calibration and were blinded to each other's rankings. We did not ask the trainees to rate the difficulty of the tasks being performed as we felt introducing this line of questioning would have interfered with the established assessment process.

Statistical Analysis

Stata release 12.1 was used for data analysis. In order to reduce the number of predictor variables representing higher-order dimensions, the TAIS subscale scores were examined for simpler underlying dimensions using 2 methods: clustering around latent variables and Mokken scaling using scale score quartiles[39]. Clustering around latent variables as a data reduction technique was used as it clusters variables rather than observations. The relationship between TAIS scores and examination performance was modeled using logistic quantile regression. In the case of examination performance, candidates' marks were converted to deciles as the basis for analysis. The use of deciles for both predictor and predicted variables allowed for the easier comparison of measures of effect size.

TABLE 2. Means and Standard Deviations of Percentile Scores on TAIS Factors

Factor	Mean Score	Standard Deviation
Confidence	71.3	24.6
Energy	61.9	28.0
Competitiveness	69.5	25.4
Extroversion	67.8	25.8
Critical	66.5	26.8
Anxiety	47.5	27.1
Distractibility	37.9	25.7
Focus over time	50.3	26.7
Performance under pressure	56.6	26.9

RESULTS

One hundred and twenty eight year-one and year-two surgical trainees took part in the technical skills assessments. The TAIS was completed by 46 year-one trainees (80%) and 56 year-two trainees (79%), giving a total participant number of 102 trainees who completed both aspects of the assessment. There was no significant difference found between the 2 years for the various TAIS factor scores and so the scores from both groups were treated as one sample. Table 2 shows the mean percentile and standard deviations for the 9 factors.

Dimensions of TAIS Factor Scores

Clustering around latent variables confirmed the 9 relevant TAIS factors. The Anxiety and Distractibility factors clustered together and these were collectively named the "negative dimension". Energy, Confidence, Competitiveness, Extroversion, Performance under pressure and self-critical clustered together and were labeled the "positive dimension". Focus over time remained a singleton. The "positive" and "negative" dimensions had a correlation of $r = -0.37$ (Fig. 1).

Mokken scaling (a statistical method of assessing whether grouped items measure the same underlying concept[44]) confirmed this structure. Two Mokken scales that emerged from the scaling were identical with the items in the clustering around latent variables analysis. The "negative dimension" had an H coefficient of 0.65, and the "positive dimension" an H coefficient of 0.55 (Table 3). Loevinger H coefficients greater than 0.50 are indicative of a strong scale.[39] Once again, Focus over time did not scale significantly with any of the other

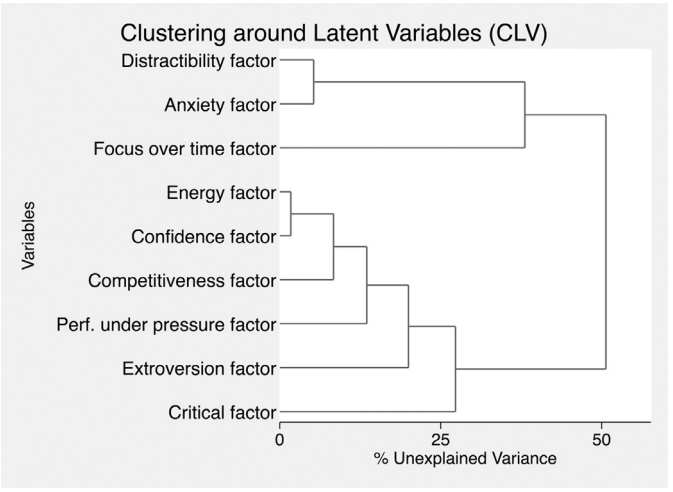

FIGURE 1. Clustering of TAIS factors around latent variables indicating TAIS dimensions.

TABLE 3. Mokken Scaling of TAIS Dimensions

Dimension	TAIS Factor/Scale	H
Negative items	Anxiety	0.65
	Distractibility	0.65
	Overall H	**0.65**
Focus over time	Focus over time	Not applicable
Positive items	Energy	0.58
	Confidence	0.73
	Competitiveness	0.57
	Perf. under pressure scale	0.54
	Extroversion	0.46
	Critical	0.43
	Overall H	**0.55**

items using the criterion of an H of 0.3 or greater as a minimum threshold for scaling.

TAIS Dimensions and Performance on Surgical Skills Assessments

There was no association between the overall examination performance and scores on the TAIS dimensions. However, examination of the individual tasks revealed associations between TAIS factor scores and two specific surgical skills assessments. The TAIS "positive dimension" was associated with the lipoma excision task and both the "positive dimension" and the "focus over time" subscale were associated with the bowel anastomosis task.

Table 4 shows the effect of a one-decile increase in the "positive dimension" and the Focus over time subscale on the candidate's decile mark in the assessment, assessed using logistic quantile regression. Where there was no significant univariate association between the predictors and the examination performance, the table shows only univariate associations.

According to the panel of experts described in the methods section, the difficulty of each task was ranked in order from least to most difficult as follows; Year-one tasks: Laceration, Lipoma excision, Laparotomy closure. Year-two tasks: Laparoscopic skills, Saphenofemoral Junction, Bowel anastomosis.

DISCUSSION

The objective of this study was to evaluate whether scores on a measure of interpersonal attributes and concentration abilities known to be related to elite performance in other fields were associated with scores on an assessment of surgical skills.

The results have demonstrated that in this sample of surgeons in training, the "positive TAIS dimension" (high levels of Energy, Confidence, Competitiveness, Extroversion, ability to perform under pressure and a low level of self-critique) was significantly associated with performance in specific surgical skills tasks; bowel anastomosis and lipoma excision. These tasks each represented one of three skills assessed in each year of training. Each of these tasks was ranked moderate-to-high difficulty for the trainees that performed them, with bowel anastomosis being considered the most complex of the 3 tasks assessed in the year-two trainees. This may indicate that the attributes listed above are more important when trainees perform more complex tasks. As discussed above, the level of difficulty in performing the task at hand impacts on the level of performance.[21] For the year-two trainees, higher performance on the most complex task was

TABLE 4. The Association between TAIS Dimensions and Surgical Examination Performance

Task	Dimension	Univariate Coefficient	Sig*	Multivariate Coefficient	Sig
Overall score	Positive	0.00	1.000		
	Negative	−0.07	0.375		
	Focus over time	−0.06	0.362		
Year-one tasks					
Laceration suturing	Positive	−0.06	0.560		
	Negative	−0.15	0.102		
	Focus over time	−0.06	0.679		
Lipoma excision	Positive	0.23	0.009	0.14	0.396
	Negative	−0.11	0.220	−0.02	0.827
	Focus over time	0.21	0.006	0.11	0.403
Incision and closure of a laparotomy wound	Positive	0.09	0.612		
	Negative	−0.06	0.593		
	Focus over time	−0.05	0.604		
Year-two tasks					
Laparoscopy	Positive	−0.11	0.385		
	Negative	0.06	0.519		
	Focus over time	0.06	0.604		
Saphenofemoral junction	Positive	0.11	0.829		
	Negative	0.53	0.189		
	Focus over time	0.46	0.207		
Bowel Anastomosis	Positive	0.28	0.008	0.28	0.005
	Negative	−0.22	0.228	0.03	0.808
	Focus over time	0.00	1.000	0.02	0.877

*$p < 0.05$.

facilitated by trainees possessing the "positive TAIS dimension" attributes. This aligns well with what we would expect at that level of training.

For the more novice year-one trainees, the lipoma task was considered the second most difficult and this was significantly associated with the "positive TAIS dimension" attributes. However, the task ranked as most difficult by the experienced faculty, laparotomy closure, was not. There are a number of possible explanations for this. One is that the level of difficulty of the laparotomy closure model was too high for this group and that the performance declined in this task despite the presence of the resilient attributes because the task pushed the trainees into the "reduced performance" downslope of the stress/performance bell curve. Another possible explanation is that trainees' perception of the "difficulty" of a simulated task may differ from the expert performers. We did not illicit the trainees perception of the difficulty of each task as this would have required the addition of a line of questioning which does not normally form part of the exam. We did not wish to alter the assessment process with this kind of intervention as we could not control for the impact this alteration could have had on performance. However, it could be considered a weakness of this study that we did not obtain that subjective trainee data as trainee perspectives would further enhance the understanding of how task "difficulty" impacts performance. The lipoma task trainer used in this study has an element of ambiguity relating to the boundaries of the lesion to be excised and this may have presented more of a challenge than the laparotomy model. Whatever the explanation, it is clear that more investigation is required to elicit the exact characteristics of specific simulated tasks and later, clinical procedures, for which possessing these "positive" resilience characteristics can lead to improved performance. Further studies could include the trainees' perspective on task difficulty and possibly subjective measures of stress for each task.

The "positive" TAIS attributes listed instinctively would seem to be beneficial for higher performance in surgery. High scores on the Energy factor are indicative of individuals who enjoy busy and challenging environments whilst low scores are indicative of individuals who perform better when they have structure and can focus on a limited number of things at a time.[43] The scales which cluster together to form the Confidence factor, provide a good indication of the extent to which the respondent has adopted a generally positive or negative response set.[43] Low scores on this factor indicate a general lack of confidence and a feeling of being out of control and it would be unusual for highly effective

individuals to score low on this factor. Individuals who score highly on the Extroversion factor are usually socially outgoing and enjoy the company of others, working better when they have other people around them.[39,43] The Competitiveness factor consists of the control (CON), self-confidence (SES) and physical competitiveness (PO) scales. High scorers are driven to be successful and want to be in control of both themselves and their environment whilst low scorers become anxious when they are required to take a leadership role.[43]

A recently published study by Rosenthal et al.[45] evaluated the relationship between personality and surgical technical skill performance. They found that of the personality traits they examined ("Big Five"), there was no trait that independently predicted technical performance on a virtual reality simulator. However, personality characteristics have otherwise been found to be associated with academic and workplace performance.[46-48] Within the field of medicine, studies have shown that certain personal qualities such as high levels of extroversion and low levels of neuroticism are an advantage for decision-making amongst surgeons.[49] Conscientiousness (hard-working, focused, and persevering) is one of the "Big Five" traits that has been most commonly associated with performance and academic success in medical students.[1,50] The TAIS measures willingness to make personal sacrifices to accomplish goals and objectives (Focus over time) and the ability to concentrate in high pressure situations (Performance under pressure). Both Focus over time and Performance under pressure resemble conscientiousness which has been described as a trait encompassing will power, initiative, responsibility and achievement striving.[62] Our study found that a high level of the scale Focus over time was found to be significantly associated with performance on the lipoma excision task. Overall, there is a paucity of studies in this area and the need for further investigation of the potential relationship between personality and technical skill proficiency.

The term "surgical personality" refers to the hypothesis that surgeons share certain personality traits.[51,52] It has been demonstrated that there is a perceived surgical personality or surgical stereotype amongst other healthcare professionals as demonstrated amongst nursing staff in a study by Warschkow et al.[53] However, this same study found that there was a significant discrepancy between the perceived surgical personality as evaluated by nursing staff and the actual surgeons' personality as assessed by the Freiburg Personality Inventory. Previous studies have examined and attempted to classify the personality type of surgeons, however, these studies have mainly been descriptive in nature and did not relate personality to surgical outcomes.[54-56] An exception to this was a study which demonstrated that there was a significant difference in the distribution of certain work related personality traits between high and low performing surgical trainees.[57] This study found that high-performing surgical trainees displayed work-related personality characteristics which mirrored those of attending surgeons. However, the personality profile for low-performing surgical trainees differed significantly from the highly performing trainees.

The importance of self-monitoring and self-awareness for surgical performance has been demonstrated.[59,60] Instinctively, therefore, the assessment of personal attributes such as interpersonal skills and concentration abilities could help trainees better understand their individual strengths and weaknesses.[58] The benefit of being attuned to one's emotional states facilitates more co-operative interpersonal relationships and aids in coping with stress within the work environment.[61] All these factors are acknowledged to be vital for the surgical trainee.

This study has certain limitations in that we examined a small number of simulated tasks and related these to one measure of interpersonal skills. The TAIS measure only found a relationship between nontechnical skills and technical performance on 2 of the 6 tasks assessed. Other measures of these attributes should be examined in the pursuit of a measurement tool which can accurately predict technical skill performance across multiple tasks and procedures. Future areas for investigation in this field should examine the detailed characteristics of specific tasks to measure technical performance and how different types of surgical tasks relate to individual interpersonal traits. Comparing scores in measurement of these traits to surgical skills performance in the clinical setting may also yield interesting insights.

CONCLUSION

This study has demonstrated that certain positive personal characteristics of surgical trainees are associated with optimal performance on specific surgical skills tasks. To our knowledge, this is the first study to demonstrate associations between personal attributes as measured by an instrument designed to assess high-performer characteristics and these technical skills. Further investigation of the relationship between personality and performance in surgery will expand our understanding of how they interact and enhance our ability to predict how future surgeons will perform.

CONFLICTS OF INTEREST

None.

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