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Fast or safe? The role of impulsiveness in laparoscopic simulator performance

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ABSTRACT

Background: Little is known about the relation between impulsiveness and surgical performance even though research in similar high-risk/high-skills shows evidence of more hazardous behavior by impulsive professionals. We investigated the impact of impulsiveness on laparoscopic simulator performance.

Methods: Eighty-three subjects participated in a four-session laparoscopic training course. Based on the Eysenck Personality test, we created equal sized high- and low impulsiveness groups and compared task duration and errors on tasks for two laparoscopic simulators.

Results: The low impulsiveness group outperformed the high impulsiveness group on damage on the LapSim virtual reality trainer ($U = 459$, $p < .049$), and showed a trend towards better error performance on the FLS videotrainer. We found no differences on task duration.

Conclusions: In surgical simulation training, high impulsiveness is associated with creating more damage, but not with faster performance. Time needed to correct errors may have obscured faster performance in the high impulsiveness group.

Summary for the table of contents: Subjects were divided into high- and low impulsiveness groups based on the Eysenck Impulsiveness Inventory test. Performance (time and errors) were compared between groups for tasks on the LapSim virtual reality trainer and FLS videotrainer. Low impulsive subjects outperformed high impulsive subjects on errors.

Introduction

Some surgeons are safer than others. However, research into individual differences between surgeons in relation to operating room performance has been limited. Two sources of individual differences have been considered in relation to surgical performance: cognitive abilities and personality. Cognitive abilities such as visuospatial ability and psychomotor ability (responsible for eye-hand coordination) are known to be somewhat related to operating room performance, especially for minimally invasive procedures such as laparoscopy.[1] While the concept of the surgical personality has attracted attention from researchers,[2–5] we found only two studies that specifically investigated the relation between personality and surgical performance.

Rosenthal et al. investigated the relation between surgical VR performance-parameters and personality, based on the results of the personality test NEO-Five Factor Inventory.[6] The NEO-FIVE Factor Inventory is a personality inventory that examines a person's Big Five personality traits (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism). Rosenthal et al. did not find any significant association.[6] Lovejoy et al. however showed that surgeons with low extraversion (i.e. introverted surgeons) tended to have better outcomes which is interesting given the consistent reports of higher extraversion in surgeons compared with the general population. The trend of more introvert trainees selected for a surgical specialty in recent years than in the past[7] may reflect a selection process for trainees that will produce better outcomes.[8] Related to the personality trait of extraversion is impulsiveness which in other fields such as traffic and aviation is associated with dangerous behavior and might play an important role in surgical performance.[9–15] The effects of impulsiveness on surgical performance however have so far received little attention from the research community.

Anecdotal evidence and OR-observations support the relevance of impulsiveness-like traits in the operating room: some surgeons are bold while others are hesitant, impacting the quality of the

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procedure being performed. Excessively bold surgeons may be fast, but more prone to cause intra-operative damage and complications, while extremely careful surgeons may work securely, but hesitant and slow. The psychological construct of impulsiveness is a good fit for this phenomenon, and basic research in psychology has demonstrated that high impulsiveness correlates with faster reaction times but more errors.[10]

To investigate the relation between impulsiveness and surgical performance, we adopted a between group design in which we compared laparoscopic simulator performance of students of high- and low impulsiveness. Students were selected as research subjects because having identical laparoscopic experience levels (namely none), either laparoscopic experience or differences in laparoscopic experience cannot bias the results. We expected that students of high impulsiveness would perform faster, but inflict more damage compared to students of low impulsiveness.

Methods

Subjects and study design

The study was performed at the skills training facility of the surgical department of the Radboud University Medical Center, Nijmegen, the Netherlands. Study participants were fourth-year medical students with no or minimal experience in laparoscopy. They voluntarily signed up for a simulator-based, four-session basic skills laparoscopic training course, offered as part of their surgical rotation preparation. This simulator-based setup allowed us to use standardized tasks and collect quantified performance data. Every month a new cohort starts with this course, and data was collected for six cohorts. Voluntary informed consent was obtained from all participating students. The study design was not reviewed by an ethical board, as this is not required for this type of research under Dutch law.

Training sessions

Self-selected groups of three students scheduled their sessions in an online calendar. The first training session took around 90 min, as besides the training exercises it included two questionnaires and an explanation of the course setup. Sessions 2–4 took around 60 min. No more than one training session per day was allowed to maintain a distributed practice schedule for better retention of skills.[13,14] All training sessions had to be scheduled within a three-week period due to the temporal constraints of the internship.

During the first session the students had to complete two questionnaires: a digital demographics questionnaire including questions about previous laparoscopic (simulator) experience, and a digital version of the Eysenck Impulsivity Inventory to collect information about impulsiveness (see 'Eysenck Impulsivity Inventory' below). In addition to these questionnaires the students received a brief introduction to the course, which included a demonstration of the principles of laparoscopic basic skills such as instrument- and camera handling. The first session was supervised, no attendant was present during the remaining three sessions.

Two training stations and one observation station were prepared for this training course. The training stations had different training hardware with different tasks. Students at the observation station assisted students at one of the training stations by collecting performance data. At the other training station performance data were automatically collected. Students started at the same station every session, and after completing all tasks of that training station they rotated to the next station. Every student completed all stations in every session (see Fig. 1).

Training stations: The LapSim VR trainer and the FLS videotrainer

LapSim VR trainer station

At the LapSim VR trainer station students performed four exercises twice on the well-validated LapSim Virtual Reality trainer (Fig. 2).[9,11,12,15] The four exercises were 'camera navigation', 'instrument navigation', 'cutting' and 'lifting and grasping'. In these tasks the student operates the camera or uses instruments such as a grasper or a ligation device in a simulated abdominal cavity to complete simple, non-procedural exercises such as ligation of blood vessels, picking up dropped gall stones, and retrieving dropped suturing needles. Detailed descriptions of the tasks can be found at the website of Surgical Science.[16]

FLS videotrainer station

Students completed three laparoscopic tasks on the FLS videotrainer: 'Peg Transfer', 'Precision Cutting' and 'Labyrinth drawing' (Fig. 2). The FLS videotrainer is a validated videobox trainer,[17–19] where students use actual laparoscopic instruments to perform simple psychomotor tasks, such as moving plastic beads from peg to peg (Peg Transfer), or use laparoscopic scissors to cut a printed shape from folded gauze (Precision Cutting). These two tasks are described on the website of Fundamentals of Laparoscopic Surgery.[20] 'Labyrinth drawing' is a self-developed task where students have to trace a path through a labyrinth using a marker attached to a laparoscopic instrument, to learn how to mitigate the effects of amplification of movement caused by working over a fulcrum. They had to perform this task both right-handed and left-handed.[21]

Observation station

The observation station consisted of a laptop running a self-developed program named 'CurveSurfer'.[21] The student at this station assisted the student training on the FLS videotrainer by keeping track of their performance and enter their scores in the software (Fig. 2). This program provides the student working on the FLS videotrainer with learning-curve feedback about his or her performance over time, contextualized by learning curves of peers and expert values.

Eysenck Impulsivity Inventory

To assess impulsiveness each student had to complete the Eysenck Impulsivity Inventory. This well validated questionnaire consists of 63 yes-no questions and was developed for the measurement of three personality traits: impulsiveness, venturesomeness, and empathy.[22–24] We were primarily interested in impulsiveness because of its known relation to damage and risky behavior in other fields, and did not further investigate venturesomeness or empathy. Impulsiveness scores were calculated after complete data collection to prevent information bias for both students and researchers during data collection.

Apparatus

The LapSim VR trainer station consisted of a desktop computer running Windows with Surgical Science's LapSim v.3.0 training software (Surgical Science, Göteborg, Sweden). Simball hardware (G-coder Systems, Västra Frölunda, Sweden) was connected to the desktop to simulate laparoscopic instruments.

The FLS videotrainer station used a videobox trainer developed by SAGES and ACS for surgical residents, fellows and practicing physicians to learn and maintain laparoscopic skills. The FLS videotrainer was connected to a 17-inch LCD monitor.

The observation station consisted of a laptop running Windows and our self-developed program 'CurveSurfer'. This is a Microsoft

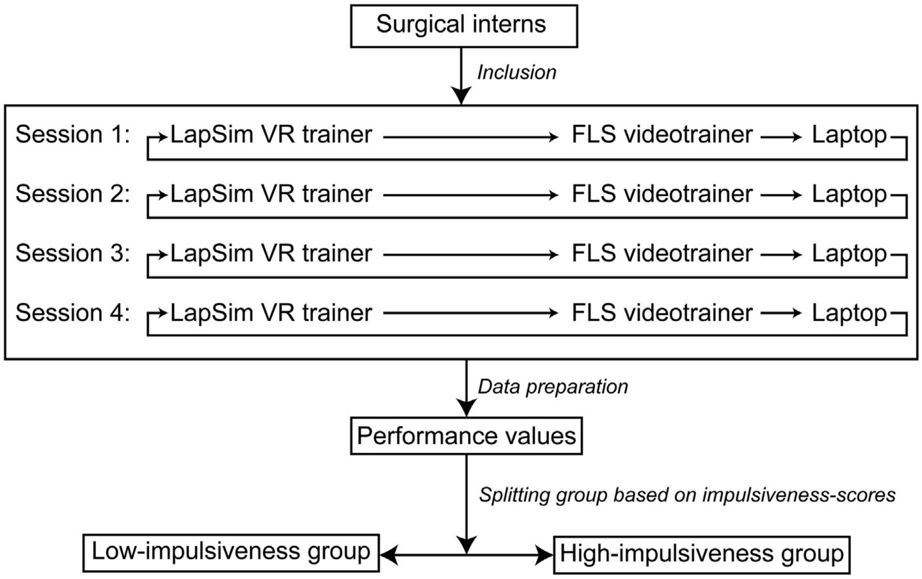


Fig. 1. Flow chart of the training course and study design.

Excel based program, designed to create learning curve feedback for students training on the FLS videotrainer.[21] Also, a digital form of the Eysenck Impulsivity Inventory was available at this station. This questionnaire was digitized with LimeSurvey version 1.92+, a web application to create surveys and collect responses.[25]

Data preparation/analysis

After all performance data was collected, the participants were split into two groups based on the results of the impulsiveness scores of the Eysenck questionnaire. If their score for impulsiveness was below or equal to the median they were assigned to the low-impulsiveness group, if their score was higher they were assigned to the high-impulsiveness group.

LapSim simulator

Performance on the LapSim Simulator was automatically registered by the simulator. Data was exported from the simulator as an Excel file. The task 'camera navigation' was used as a warming-up exercise, and was not included in the analysis. Registered performance parameters were overall score, instrument path length, angular path, tissue damage, maximum damage, and instrument time. As we were interested in differences in speed and damage control, only parameters representing these aspects were analyzed: instrument time, tissue damage and maximum damage. Tissue damage represents the number of incidents, maximum damage the deepest 'wound' inflicted in mm.

To analyze the differences between the two experimental groups over the whole course rather than over individual training sessions, we averaged ranked performance data for each parameter of the three individual sessions. To achieve one overall parameter for damage, the parameters 'tissue damage' and 'maximum damage' were combined by calculating the average of these ranks.

This resulted in two parameters per exercise: time and damage. In addition, the time and damage parameters were averaged over all three exercises to create overall LapSim performance parameters for time and damage. Mann-Whitney U tests were done to compare time and damage per exercise and for all exercises combined between the high- and low impulsiveness groups.

FLS videotrainer

The FLS videotrainer does not automatically register performance, therefore all exercises of this training station were video recorded and performance was afterwards manually scored by two authors (BK and WIJ), who were blinded for the results of the impulsiveness test. Tasks were scored for total time and errors made (bead drops during peg transfer). Only data of the task 'peg-transfer' was used, as the task 'labyrinth drawing' is not yet validated and for the task 'precision cutting' the videos did not allow for scoring errors objectively.

To cluster the four sessions, we followed the same procedure as described for the LapSim Simulator above, where we converted the

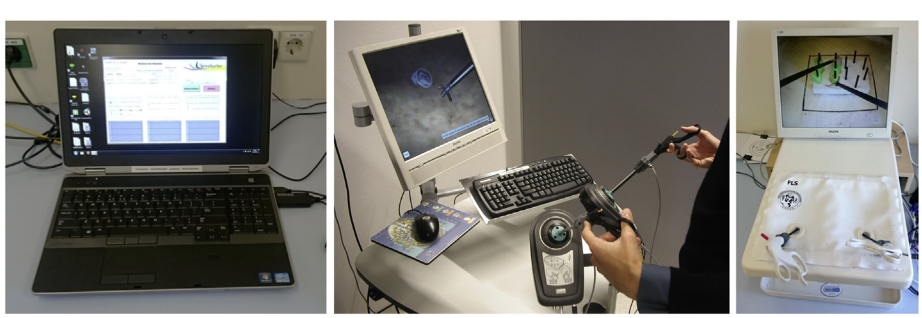


Fig. 2. Pictures of the three training stations from left to right: observation station, LapSim VR trainer and the FLS videotrainer.

interval data to ordinal data by ranking the parameters and calculated the average ranks over four sessions for time and errors made. We performed Mann-Whitney U tests for total time and total errors made over the four sessions to compare the two experimental groups.

The alpha level was set at 0.05 for all tests.

Results

Participants

Eighty-three students of six cohorts (51.0% of the total amount of students preparing for their surgical rotation) signed up for the voluntary laparoscopic basic skills training course and were eligible for this study. Seventy-three participants completed a minimum of three sessions which was considered mandatory for inclusion in the study. Lost data due to technical problems occurred for two subjects, data of both were excluded. Consequently, data of 71 students were included in the analysis.

Age ranged between 21 and 30 years (mean 23.8 years) and 22 participants were male (31.0%). Two participants reported previous laparoscopic experience, only having operated the camera. Their performance was between the first and third quartile for both damage and speed. Both impulsiveness groups were comparable regarding age, gender and laparoscopic experience (Table 1).

Influence of impulsiveness on laparoscopic performance

LapSim simulator

A summary of the results of the LapSim Simulator is shown in Fig. 3. Subjects of low impulsiveness had lower scores for damage on every task, which means they caused less damage. This reached significance only when performance of all tasks was averaged ($U = 148$, $p = .049$). Total time did not differ significantly between the two groups for any task individually, nor did it for all tasks combined. Neither did one group structurally outperform the other on time.

FLS videotrainer

Fig. 4 shows similar trends of performance regarding the FLS videotrainer data. The low impulsiveness group made fewer errors over four sessions. The low impulsiveness group was marginally faster compared to the high impulsiveness group. The differences for time and errors, however, were not significant.

Discussion

Students of low impulsiveness outperformed students of high impulsiveness on all damage and error measures collected during a basic skills laparoscopic training course. However, this only reached significance for the averaged damage variables on the LapSim VR trainer. In contrast to our expectations, we found no differences in performance for duration variables. A possible explanation is that faster performance may have been obscured by the extra time needed to correct errors. Also, the exercises were both simple and predictable and students of low impulsiveness may not have needed extra time to carefully assess the situation, which would have slowed them down compared to students of high impulsiveness. In the operating room surgery is complex and unpredictable, which could slow down low-impulsiveness surgeons who need more time for premeditation, which would lead to our expected time/damage trade-off.

When we compare our results to earlier studies in other sectors we see similar results. In traffic, studies show that young drivers who score high on the Barratt impulsiveness scale, another validated test that measures impulsiveness,[26,27] are more likely to drive risky, drive aggressively, lose concentration, lose car control, cause traffic violations and make mistakes.[28,29] In 2013, Pearson used a five-factor model of impulsiveness-like traits to investigate a possible correlation of these traits with four risky driving behaviors.[30] All correlations showed the same trend: impulsiveness-like traits increase risky driving behavior.

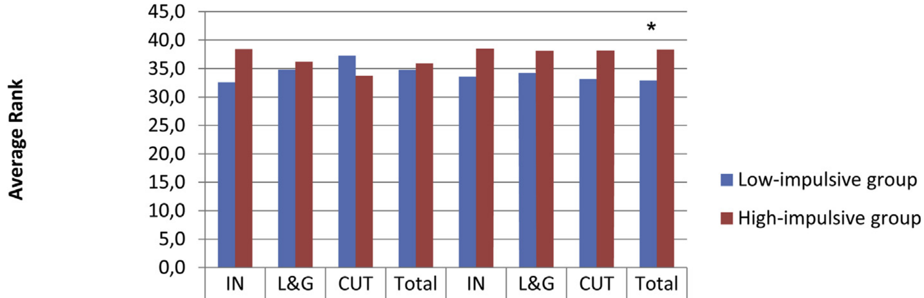
The Federal Aviation Administration suggests a relation between attitudes and incidents in aviation as well.[31] Anti-authority, impulsiveness, invulnerability, machoism and resignation are recognized by this organization as hazardous attitudes. They believe, however, that good judgment can be taught. Therefore they have created a structured, systematic model to analyze changes during a flight to decrease the probability of human error and increase the probability of a safe flight.[31] Pilots are trained to recognize and counteract hazardous attitudes like impulsiveness via this model (Fig. 5). When tested, pilots who received this kind of decision-making training made fewer in-flight errors than those who had not.[31] For laparoscopic simulation training applying this systematic model may be beneficial decreasing error and increasing safety.

As a thought exercise, we apply the six-step FAA model to a situation where a resident is stopping a bleeding. The first step is recognizing the personal hazards e.g. an impulsive attitude of 'quickly do something' meaning directly taking actions trying to control the bleeding. Instead the resident determines the risk of the bleeding e.g. which vessel is bleeding, what are the consequences? Third step is considering the options to fix the problem e.g. ligating the vessel, closing the hole in the vessel or put digital pressure on the vessel. During the fourth step a decision is made about the mode of action after quickly weighing pros and cons of the options e.g. it is an important artery or vein that need to be saved and thus need to be repaired. After performing the repair (the fifth step), the last step is monitoring the main results of the decision, the bleeding has stopped and the blood flow is successfully restored. To implement this model in a training course, the procedures to be trained would need to be subjected to safety critical task analysis or cognitive task analysis with an emphasis on errors and damage control.[32] Potential errors, damage, complications, their origins and their consequences are defined as main outcomes of the training course. In this way, trainees of known levels of impulsiveness can be steered towards appropriate steps through the training environment.

Besides counteracting hazardous attitudes, knowledge on the relation between impulsiveness and adverse incidents also offers an opportunity to design personalized adaptive training programs. For students of high-impulsiveness for example this could mean focusing training on damage control, possibly by creating a training that steers the students' emphasis to one specific outcome parameter, a method we are currently testing.

Table 1
Summary of characteristics of study participants.

	Low-impulsiveness group $n = 36$	High-impulsiveness group $n = 35$
Sex (male, *n*)	10 (27.8%)	12 (34.3%)
Age (mean)	23.5 years (22–30 years)	24 years (21–29 years)
Laparoscopic experience (*n*)	1 (2.8%)	1 (2.9%)
Impulsiveness-score	1.64 (.46–2.81)	4.25 (2.83–7.15)



	Time				Damage			
	IN	L&G	CUT	Total	IN	L&G	CUT	Total
Low-impulsive group	32,6	34,8	37,3	34.9	33,0	34.0	33.8	33.6
High-impulsive group	38,4	36,2	33,7	36.1	38,0	37.4	37.6	37.6
U-value	470	583	547	597	528	512	482	459
p-value	.065	.589	.337	.704	.241	.175	.089	**.049***

Fig. 3. Display of performance (shown as average ranks for time and damage) of the three LapSim VR trainer tasks individually and combined (total). Low ranks mean less time was used and fewer errors were made compared to high ranks. All four training sessions are combined. Blue bars represent performance of the low impulsiveness group, red bars represent performance of the high impulsiveness group. U-values and *p*-values of Mann-Whitney U tests are shown per exercise and for the total score. Abbreviations of exercises: IN = instrument navigation, L&G = lifting and grasping, CUT = Cutting. * = $p < .05$. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Limitations

The results of this research are based on simulated laparoscopy, which differs from real world laparoscopy in a number of ways. Laparoscopy as performed in the OR is more complex, unpredictable, and harbors risk of (life threatening) complications. All these differences might interact with the personality trait impulsiveness. Simulators, however, allow for objective, quantified measurement of damage, which is much harder to do in the operating room.

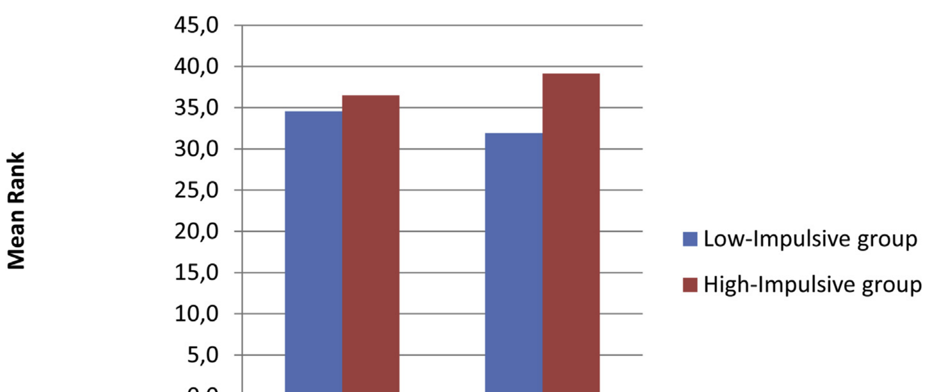
During the first session of the LapSim Simulator task ‘instrument navigation’ 20.0% of the high impulsiveness group and 16.7% of low impulsiveness group reached the time limit for this exercise. During the remaining sessions this limit was reached by less than 2% of the students. We may have underestimated differences in time between the two experimental groups in the first session for this simulator. This difference however would have worked against our hypotheses, and has not changed our results.

Another limitation is that students differ from attending surgeons in professional experience. With experience psychomotor skills improve and automate. As a consequence, performance differences attenuate over time and become less sensitive to individual differences.[33] Working with 4th year medical students however ensured identical experience levels for all participants, reducing the risk for confounding variables.

Future research

Having established a negative impact of impulsiveness on student performance in a simplified surgical simulation environment, research is needed to extrapolate these findings to surgeons of different experience levels, preferably in a real-world setting.

Another line of research would be in personalized training. Is it for instance possible to counteract the effects of high impulsiveness by changing assessment variables? We are currently analyzing data



	Time	Errors
Low-Impulsive group	34,5	31,9
High-Impulsive group	36,5	39,1
U-value	596	560
p-value	.346	.209

Fig. 4. Performance (time and errors) of both experimental groups on the FLS videotrainer. Low ranks mean less time and fewer errors made compared to high ranks. All four training sessions are combined. The blue bars represent the performance of the low impulsiveness group, red bars represent performance of the high impulsiveness group. U-values and *p*-values of Mann-Whitney U tests are shown per parameter. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

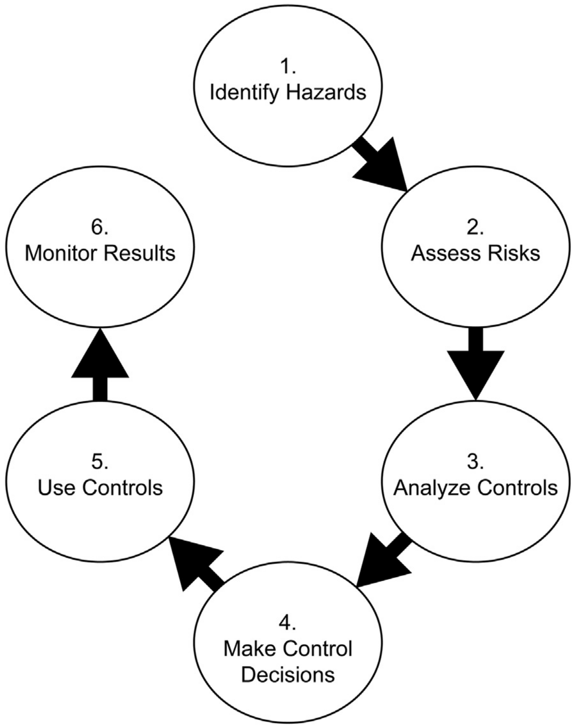


Fig. 5. Schematic display of the steps of the risk management decision-making process as introduced by the FAA.

from a study where students get feedback on either speed or damage control during simulator training, taking into account differences in impulsiveness.

Conclusion

The personality trait impulsiveness influences laparoscopic simulator performance; low impulsiveness students create less damage, yet are as fast as high impulsiveness students. More research is needed to learn about the relevance of impulsiveness for performance in the OR and for surgeons of different experience levels. If such studies corroborate our findings, the personality trait of impulsiveness may have implications for professional selection and the design of surgical training programs.

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Declaration of competing interest

For all authors no conflict of interest were declared.

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