MEDICAL UNIVERSITY OF VIENNA

Study Protocol

The Influence of Classical Music on Performance in Robotic Surgical Simulation

Department of Obstetrics and Gynecology,

Division of General Gynecology and Gynecologic Oncology

Medical University of Vienna

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1 Background

Acoustic environmental influences are increasingly recognized as relevant factors in clinical working environments. Background noise, conversations, technical alarms, as well as deliberately used music can influence cognitive processes, attention, motor control, and physiological stress responses. Several experimental studies have demonstrated that auditory stimuli can measurably modulate cognitive workload (Gigliotti et al., 2025), motor coordination and fine motor skills (Sarıçamlık et al., 2025), as well as stress and arousal levels (Kiss et al., 2025) in complex and time-critical tasks. These findings are particularly relevant for surgery, where precise psychomotor performance, sustained attention, and situational decision-making are essential prerequisites for patient safety and operative quality.

In clinical practice, music in the operating room is widely used and is often perceived by surgical staff as mood-enhancing, stress-reducing, or concentration-supporting (Fu et al., 2021; Narayanan et al., 2022). At the same time, evidence suggests that certain types of music or distracting auditory stimuli (e.g., conversations, device noise, or alarm signals) may negatively influence or variably modulate performance in demanding motor-cognitive tasks (Mentis et al., 2016; Fancourt et al., 2016). However, the current evidence base is heterogeneous: most studies focus on laparoscopic simulation settings (Oomens et al., 2019) or observational designs (Boghdady et al., 2020). For robotic-assisted surgery, only a limited number of controlled experimental studies exist, and these primarily investigate general distraction or mixed auditory conditions (Krüger et al., 2020; Siu et al., 2010). To date (April 2026), no studies have specifically investigated the effect of classical music in robotic surgical simulation.

There is a particular need for research in robotic surgery, as the interaction between surgeon, console, and sensory environment differs substantially from conventional surgical procedures. Therefore, findings from other surgical contexts cannot be directly transferred. A standardized simulation environment allows for the controlled manipulation of influencing factors such as training level, task type, duration, and auditory stimuli, while objectively measuring performance via system-generated scores without risk to patients.

2 Study Objective

The aim of this experimental, prospective study is to systematically investigate the influence of classical music on operative performance in robotic surgical simulation training.
Specifically, it will be assessed whether performance in a da Vinci simulator differs under standardized conditions depending on auditory environment.
The study seeks to determine whether listening to classical music in the operating room supports, does not affect, or potentially impairs performance. The results are intended to provide a more evidence-based foundation for the use of music in robotic surgical settings, particularly in training and educational contexts. While some insights may be applicable to clinical practice, real surgical environments include additional dynamic factors (e.g., team interaction, workflow variability, unforeseen events) that cannot be fully replicated in

simulation. Therefore, direct transferability is limited, but the controlled environment allows isolation of auditory effects.

3 Study Design

This is an experimental, randomized cross-over study conducted using a da Vinci surgical simulator. Participants will perform standardized exercises under two auditory conditions:

1. No music exposure
2. Listening to classical music

A training phase will precede testing to familiarize participants with the simulator. Each participant will complete predefined tasks once without auditory stimulation and once while classical music is played via speakers. Participants will be randomly assigned to one of two sequences: half will start with no music and half with classical music. The classical music condition consists of Mozart's Clarinet Concerto in A major, K.622: II. Adagio.

Performance will be assessed using the simulator's objective trainer score. After each session, participants will complete questionnaires assessing subjective workload (SURG-TLX) and additional self-assessment measures.

4 Participants

Participants will be recruited voluntarily from human medicine students. Recruitment will be conducted verbally during teaching sessions at the Department of Gynecology. Interested individuals may register via email and will receive study information and informed consent documents.

Prior to inclusion, all participants will receive written information regarding study purpose, procedures, duration, potential burdens, voluntary participation, data handling, and the right to withdraw. Informed consent will be obtained in person by a trained study team member, who will also answer any questions.

Participation or non-participation will have no influence on academic grading or training progression. Enrollment will follow a first-come, first-served principle, considering inclusion and exclusion criteria, until the required sample size is reached.

4.1 Inclusion Criteria

- Age ≥ 18 years
- Medical students between the 1st and 12th completed semester
- No prior experience in robotic surgery required
- Basic familiarity with technical devices required
- Sufficient German or English language skills for informed consent and instruction comprehension

4.2 Exclusion Criteria

- Lack of capacity to provide informed consent
- Insufficient German or English language skills
- Known hypersensitivity to noise
- Hearing or balance disorders
- Conditions significantly affecting attention or motor skills (e.g., tremor, myopathies)
- Acute illness, substance influence, or severe fatigue
- Direct dependency or evaluative relationship with study personnel

5 Parameters

The primary outcome is objective performance in the robotic simulator, automatically calculated by the system based on total completion time, error rate, and task precision. The score will be recorded under both auditory conditions.

Secondary outcomes include subjective workload and perception measures, assessed using the SURG-TLX questionnaire (including subscales for mental and physical workload, time pressure, task complexity, stress, and distraction) and an additional short self-assessment questionnaire.

Demographic variables will also be collected (age, sex, handedness, training level, prior experience with robotic surgery/simulation, music consumption habits) to allow adjustment for potential confounders.

Table 1: Overview of Variables

Variable	Unit/Categories	Type	Timepoint	Source
ID	1-20	Metric	Recruitment	Sequential assignment
Age	Years	Metric	Study entry	ID card
Sex	Male / Female / Diverse / Other / No answer	Nominal	Study entry	Participant
Handedness	Right / left / ambidext	Nominal	Study entry	Participant
Training level	Completed semesters (1-11)	Metric	Study entry	MedCampus University system
Robotic experience	None / observation / low / moderate / high	Ordinal	Study entry	Participant
Music consumption	Daily / occasional / rare / never	Ordinal	Recruitment	Participant
Music genre	e.g., classical music, Hip-Hop, Pop…	Nominal	Recruitment	Participant
Simulator score	%	Metric	After each session	Simulator
SURG-TLX	0-20 per domain	Ordinal	After each session	Participant
Subjective performance	1-10	Metric	After each session	Participant
Subjective distraction	1-10	Metric	After each session	Participant
Perceived support	1-10	Metric	After each session	Participant

5.1 Primary Outcome

The primary outcome is the change in objective performance score in the robotic simulation under the two conditions (no music vs. classical music). Both absolute scores and within-subject differences in the cross-over design will be analyzed.

5.2 Secondary Outcomes

Secondary outcomes include perceived workload and subjective experience (SURG-TLX and additional questionnaire) under both conditions and within-subject comparison.

6 Methods

This is a prospective experimental cross-over study conducted in a robotic surgical simulator under two auditory conditions (no music, classical music). Medical students without extensive robotic surgery experience will be included. After consent and baseline data collection, participants receive a unique ID determining group allocation:

- Even IDs: Group 1
- Odd IDs: Group 2

Following a standardized training phase, participants complete the same simulator module under both conditions in alternating order depending on group assignment. Between sessions, a short break is provided.

After each session, performance scores and subjective workload questionnaires are collected. A final feedback discussion allows participants to report subjective impressions.

6.1 Statistical Analysis

Data will be analyzed within a cross-over, within-subject framework. Paired t-tests will be used for normally distributed variables; otherwise, Wilcoxon signed-rank tests will be applied.

Descriptive demographic data will be presented using frequency tables and/or bar charts.

6.1.1 Primary Analysis

The primary objective is to evaluate the effect of classical music on performance, concentration, and workload in robotic simulation. The primary endpoint is the within-subject difference in performance score between conditions.

6.1.2 Secondary Analysis

Secondary analyses examine the effect of auditory conditions on subjective workload, stress, and perceived performance.

6.1.3 Multiplicity

Not applicable.

6.1.4 Sample Size Justification

Due to the cross-over design, inter-individual variability is reduced. Based on comparable studies, a moderate effect size is expected. A sample size of approximately 18-20 participants is required; therefore, at least 20 participants will be recruited to account for potential dropouts.

7 Data Protection

Data will be pseudonymized using sequential numeric IDs. The identification key will be stored separately in a password-protected file accessible only to the study team. Data will be stored on secure internal servers. Publication will only occur in anonymized form.

8 Risk-Benefit Assessment

The study is conducted in a simulation environment without patient contact or medical intervention. Potential burden is limited to short-term cognitive load and concentration effort. Minimal risk includes temporary fatigue or mild discomfort due to sensory load. Participants may pause or withdraw at any time without disadvantage.

No physical, psychological, or data protection risks beyond standard educational training settings are expected. Data are pseudonymized and used exclusively for research purposes.

The expected benefit lies in improved understanding of auditory influences on surgical performance, potentially optimizing training environments and surgical workflow design. Overall, the benefit–risk ratio is considered clearly favorable.

9 Appendix

9.1 Abbreviations

ID, Identification number
OP, Operation
SURG-TLX, The Surgery Task Load Index (SURG-TLX)

9.2 References

- Gigliotti, M., Lauret, D., & Delevoye-Turrell, Y. (2025). The sonic energy of background music impacts cognitive performances: a behavioral and physiological investigation. *Cognitive Research: Principles and Implications*, 10. https://doi.org/10.1186/s41235-025-00676-9.
- Sarıçamlık, S., Avcı, N., & Yiğit, Ö. (2025). The Role of Background Acoustic Stimuli in Dual Tasks: A Study on Postural Control Performance. Brain and Behavior, 15. https://doi.org/10.1002/brb3.70750.
- Kiss, L., & Linnell, K. (2024). The role of mood and arousal in the effect of background music on attentional state and performance during a sustained attention task. Scientific Reports, 14. https://doi.org/10.1038/s41598-024-60218-z.
- Fu, V. X., Oomens, P., Merkus, N., & Jeekel, J. (2021). The Perception and Attitude Toward Noise and Music in the Operating Room: A Systematic Review. The Journal of surgical research, 263, 193–206. https://doi.org/10.1016/j.jss.2021.01.038
- Narayanan, A., Pearson, L., Fisher, J., & Khashram, M. (2022). The effect of background music on stress in the operating surgeon: scoping review. BJS Open, 6. https://doi.org/10.1093/bjsopen/zrac112.
- Mentis, H., Chellali, A., Manser, K., Cao, C., & Schwaitzberg, S. (2016). A systematic review of the effect of distraction on surgeon performance: directions for operating room policy and surgical training. Surgical Endoscopy, 30, 1713-1724. https://doi.org/10.1007/s00464-015-4443-z.
- Fancourt, D., Burton, T., & Williamon, A. (2016). The razor's edge: Australian rock music impairs men's performance when pretending to be a surgeon. Medical Journal of Australia, 205. https://doi.org/10.5694/mja16.01045.
- Oomens, P., Fu, V. X., Kleinrensink, G. J., & Jeekel, J. (2019). The effect of music on simulated surgical performance: a systematic review. Surgical endoscopy, 33(9), 2774–2784. https://doi.org/10.1007/s00464-019-06868-x
- El Boghdady, M., & Ewalds-Kvist, B. M. (2020). The influence of music on the surgical task performance: A systematic review. International journal of surgery (London, England), 73, 101–112. https://doi.org/10.1016/j.ijsu.2019.11.012
- Krüger, M., Ackermann, J., Osmonov, D., Günther, V., Bauerschlag, D., Hensler, J., Egberts, J. H., Lippross, S., Gitas, G., Becker, T., Maass, N., Jünemann, K. P., & Alkatout, I. (2020). Impact of Acoustic and Interactive Disruptive Factors during Robot-Assisted Surgery-A Virtual Surgical Training Model. Sensors (Basel, Switzerland), 20(20), 5891. https://doi.org/10.3390/s20205891
- Siu, K.-C., Suh, I. H., Mukherjee, M., Oleynikov, D., & Stergiou, N. (2010). The effect of music on robot-assisted laparoscopic surgical performance. Surgical Innovation, 17(4), 306–311. https://doi.org/10.1177/1553350610381087

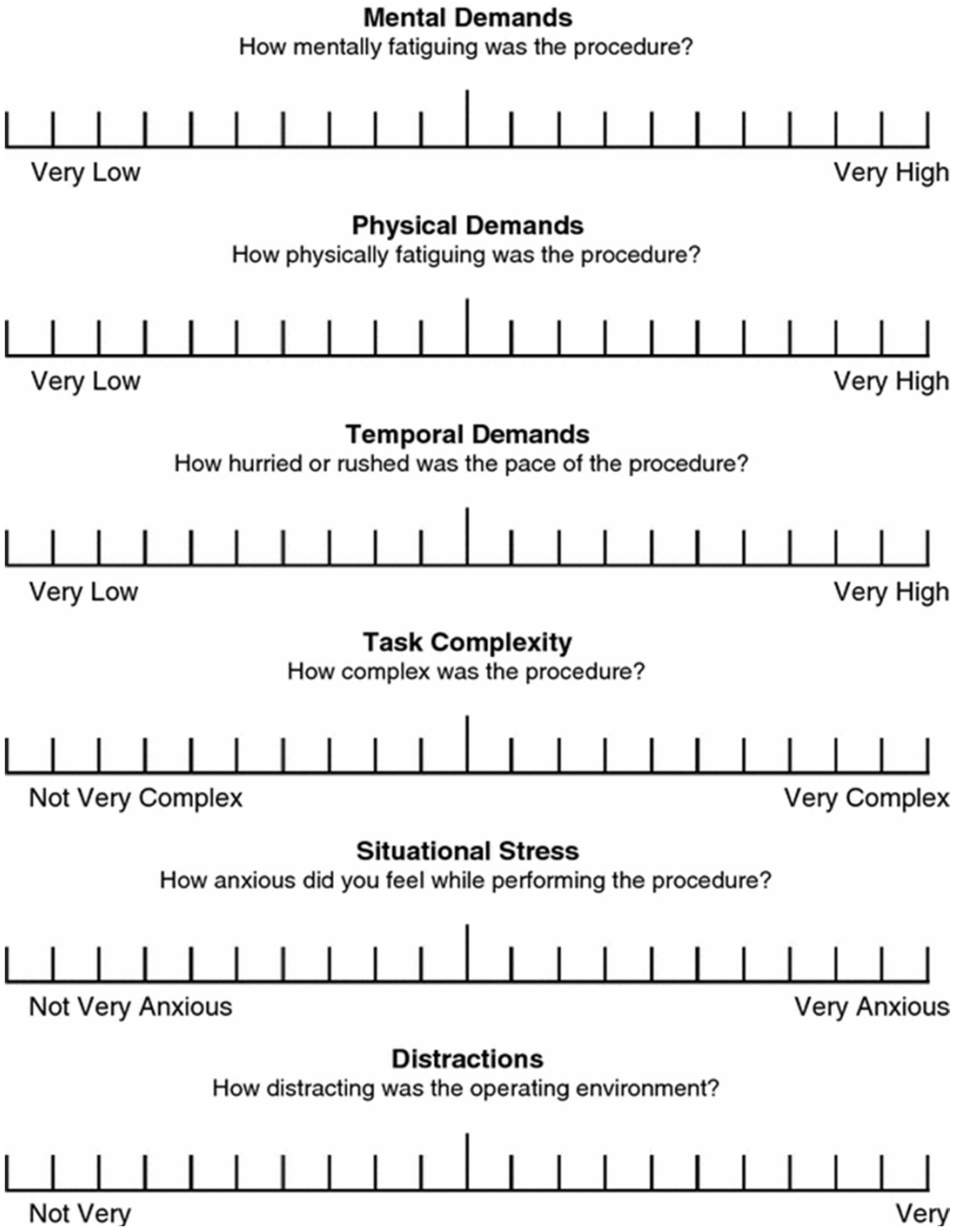
- Wilson MR, Poolton JM, Malhotra N, Ngo K, Bright E, Masters RS. Development and validation of a surgical workload measure: the surgery task load index (SURG-TLX). World J Surg. 2011 Sep;35(9):1961-9. doi: 10.1007/s00268-011-1141-4. PMID: 21597890; PMCID: PMC3152702.

9.3 Additional Questionnaire

1. "I felt that my performance in this task was good."
    - 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10
    - 0: does not apply at all / 10: fully applies
2. "I felt distracted by the auditory conditions."
    - 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10
    - 0: does not apply at all / 10: fully applies
3. "I felt supported by the auditory conditions."
    - 0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10
    - 0: does not apply at all / 10: fully applies

9.4 SURG-TLX Questionnaire

Source: Wilson MR, Poolton JM, Malhotra N, Ngo K, Bright E, Masters RS. Development and validation of a surgical workload measure: the surgery task load index (SURG-TLX). World J Surg. 2011 Sep;35(9):1961-9. doi: 10.1007/s00268-011-1141-4. PMID: 21597890; PMCID: PMC3152702.


Mental Demands
How mentally fatiguing was the procedure?
Very Low
Very High
Physical Demands
How physically fatiguing was the procedure?
Very Low
Very High
Temporal Demands
How hurried or rushed was the pace of the procedure?
Very Low
Very High
Task Complexity
How complex was the procedure?
Not Very Complex
Very Complex
Situational Stress
How anxious did you feel while performing the procedure?
Not Very Anxious
Very Anxious
Distractions
How distracting was the operating environment?
Not Very
Very