Surg Endosc (2008) 22:2416–2420
DOI 10.1007/s00464-008-0040-8

Randomized controlled trial investigating the effect of music on the virtual reality laparoscopic learning performance of novice surgeons

D. Miskovic · R. Rosenthal · U. Zingg · D. Oertli · U. Metzger · L. Jancke

Received: 26 December 2007 / Accepted: 27 March 2008 / Published online: 12 July 2008

Abstract
Background Findings have shown that music affects cognitive performance, but little is known about its influence on surgical performance. The hypothesis of this randomized controlled trial was that arousing (activating) music has a beneficial effect on the surgical performance of novice surgeons in the setting of a laparoscopic virtual reality task.
Methods For this study, 45 junior surgeons with no previous laparoscopic experience were randomly assigned to three equal groups. Group 1 listened to activating music; group 2 listened to deactivating music; and group 3 had no music (control) while each participant solved a surgical task five times on a virtual laparoscopic simulator. The assessed global task score, the total task time, the instrument travel distances, and the surgeons' heart rate were assessed.
Results All surgical performance parameters improved significantly with experience (task repetition). The global score showed a trend for a between-groups difference, suggesting that the group listening to activating music had the worst performance. This observation was supported by a significant between-groups difference for the first trial but not subsequent trials (activating music, 35 points; deactivating music, 66 points; no music, 91 points; $p = 0.002$). The global score ($p = 0.056$) and total task time ($p = 0.065$) showed a trend toward improvement when participants considered the music pleasant rather than unpleasant.
Conclusions Music in the operating theater may have a distracting effect on novice surgeons performing new tasks. Surgical trainers should consider categorically switching off music during teaching procedures.

Keywords Laparoscopy · Music · Performance · Simulation · Surgical training/courses

In many hospitals, it is common practice to play music in the operating theater during surgical procedures [1]. Some surgeons claim to perform better with music, but others fear it has a potentially disturbing influence [2]. Numerous studies have previously investigated the possible effects of listening to music on psychological functions. Rauscher et al. [3], who introduced the so-called Mozart effect, showed that students increased their spatial processing performance after simply listening for 15 min to a Mozart sonata. This remarkable result seemed to indicate that human cognition could be manipulated positively by a simple intervention not requiring intensive and explicit learning. Unfortunately, the results were not reproducible in follow-up studies [4]. However, although the original Mozart effect is disputable, there is no doubt that music has a strong influence on various psychological functions including emotion, verbal memory, and even intelligence [5–10].

In contrast, empirical evidence supporting proposed positive or negative influences of listening to music

D. Miskovic · U. Metzger
Department of Surgery, Triemli Hospital, Zurich, Switzerland

D. Miskovic (✉)
38 Pearman Street, London SE1 7RB, UK
e-mail: miskovic@gmx.ch

R. Rosenthal · U. Zingg · D. Oertli
Department of Surgery, University Hospital, Basel, Switzerland

L. Jancke
Institute of Neuropsychology, University of Zurich, Zurich, Switzerland

during surgery is sparse. Allen and Blascovich [11] showed that surgeons who regularly listened to music in the operating theater solved mental arithmetical tasks better after they had listened to music of their choice. Additionally, their autonomic response was less pronounced. The participants in another study were able to judge vital sign trends on an anesthesia monitoring device more accurately while listening to music [12]. However, the impact of music on the surgeon's manual performance was never examined properly, and there is little evidence for or against the usefulness of music in the operating theater.

To examine whether listening to music during surgery might influence surgical performance, we designed the current study. In this study, the participants were required to conduct virtual surgical procedures while listening to musical pieces of different emotional valence and intensity. Our hypothesis was that the surgical performance of novice surgeons would be enhanced under emotionally arousing or activating musical stimulation. On the other hand, we hypothesized that deactivating or sedating musical pieces would have an opposite impact.

Materials and methods

Participants

The experiment enrolled 45 junior surgeons (20 men and 25 women) with a mean age of 31 years (range, 25–46) years) and no previous laparoscopic experience. The group size was chosen according to previous studies with a similar study design [13, 14]. Those who had experience with laparoscopic surgery or endoscopic procedures were excluded to rule out the potential for bias resulting from different levels of experience. None of the participants experienced neurologic or psychiatric diseases.

Before performing the task, the participants were asked about their musical preferences and their experience with video games. Dexterity and handedness were tested by a standard hand performance test (O'Connor Dexterity Test, Lafayette Instruments Inc., Lafayette, IN, USA), and hand preference was tested by line tracing and point tapping [15, 16]. To evaluate the pretest mood state of the participants, we used a reliable self-evaluation sheet (Adjektiv-Skalen zur Einschäetzung der Stimmung (SES) by Hampel) [17].

Laparoscopy simulator and setting

The participants were asked to work on a laparoscopic simulator (Xitact LS500; XITact SA, Vevey, Switzerland). The task consisted of clipping and cutting the cystic duct and artery as a part of the laparoscopic cholecystectomy procedure. The participants were randomly allocated to one of three groups: group 1 (active: exposed to activating music), group 2 (deactive: exposed to deactivating music), and group 3 (no music: not exposed to music).

After a single presentation of the task by the supervisor, the participants were asked to perform the same surgical task five times, during which groups 1 and 2 were listening to the allotted music. We used the LS500 (Xitact) virtual patient laparoscopy simulator, run by a Pentium PC with a high-resolution thin film transistor (TFT) monitor connected to two robotic force feedback devices acting as interfaces for the laparoscopic instruments. A selection of instruments such as graspers, scissors, and clip applier was available. We used two different scores calculated by the integrated software: the global score comprising the anatomy scores (accuracy of cystic duct and artery clipping) minus the error score (e.g., clipping errors, cutting errors, bleeding), with a minimum score of 0. We also used the total task time as well as the left and right hand travel distances. These parameters represent most accurately the quality of task performance [18–20].

Music

The different pieces of music were chosen by the authors according to previously conducted studies to activate or deactivate the participants [8, 9]. We used, for example, Richard Wagner's "Valkyrie" to evoke an activated mental condition, or certain tracks by Nicholas Gunn (e.g., "Seeking Serenity") for the opposite effect. Music was played on a computer with a constant volume of 35 dB (iTunes 7.0 l; Apple Inc., Cupertino, CA, USA). The participants evaluated the musical pieces on a visual analog scale relating to the subjectively experienced emotional valence (pleasant vs. unpleasant).

Statistical analysis

Global score, total task time, and right and left instrument travel distance were used as dependent variables. The surgical error score representing the total number of typical surgical errors was incorporated into the calculation of the global score. Thus, there was a strong correlation between the global and error scores. These dependent variables were subjected to two-way analysis of variance (ANOVA) using one grouping factor (groups 1–3) and one repeated measurement factor, with five levels representing the five repetitions ("experience"). For testing of the repeated measurements factor and the corresponding interaction with the grouping factor, the multivariate variant of repeated measurements ANOVA was used [21].

Results

Participants

There were no statistically significant differences between the three groups in terms of age, gender, dexterity, handedness, or experience with video games. There was no significant difference in general pretest mood levels as measured in the SES test (Table 1).

Performance measures

The total task time dropped significantly with increasing experience (increasing trial number) in all three groups, from an average of 205 s in the first trial to 146 s of the fifth trial ($F[4,39] = 13.0$; $p < 0.001$; $ETA^2 = 0.57$). The decrease was clearly linear, representing the first part of a logarithmic learning curve ($F[1,42] = 43.17$; $p < 0.001$; $ETA^2 = 0.51$). However, there was no significant difference between the groups. The global score, representing performance accuracy, increased with experience, from an average of 64 points in the first trial to 124 points in the last trial ($F[4,39] = 4.7$; $p = 0.003$; $ETA^2 = 0.33$). The group effect was not significant, but there was a trend for an interaction between the grouping factor and experience ($F[8,78] = 1.74$; $p = 0.10$; $ETA^2 = 0.15$). This trend for an interaction was qualified by a highly significant between-groups difference in the first trial (group 1, 35 points; group 2, 66 points; group 3, 91 points; $F[2,42] = 7.13$; $p = 0.002$; $ETA^2 = 0.25$) but not in the four subsequent trials (Fig. 1).

The right instrument travel distance also decreased with experience (trial 1, 2.27 m; trial 5, 1.97 m; $F[4,39] = 4.1$; $p = 0.007$; $ETA^2 = 0.29$). There was neither a further main effect nor an interaction approaching significance. The decrease was again qualified by a strong linear trend ($F[1,42] = 10.1$; $p = 0.003$; $ETA^2 = 0.19$) representing increasing economy of the dominant right hand movements. There was no between-groups difference for left instrument travel distance.

To analyze whether emotional valence might affect surgical proficiency, we reallocated the participants who listened to music into two new groups. Group A responded to the question about whether the music evoked pleasant emotions with scores from 1 to 3 (12 pleasant), group B with scores from 4 to 6 (17 unpleasant), and group C (15 no music). The two-way ANOVA (with a two-level grouping factor) for the parameters global score and total task time showed a trend for a between-groups interaction for experience ($F[4,24] = 2.7$; $p = 0.056$; $ETA^2 = 0.31$ for global score; $F[1,27] = 3.7$; $p = 0.065$; $ETA^2 = 0.28$ for total task time). This interaction was qualified by a stronger difference in the first three trials, with participants who considered the music more pleasant generally completing the task better and faster. The participants in group A (pleasant) solved the task in the first three trials after 157 s, whereas it took 198 s for group B and 192 s for group C. However, the parameters adapted to the performance level of the other group in the final two sessions, and there was no overall difference between the two groups (group A, 145 s; group B, 159 s; group C, 164 s) (Fig. 2).

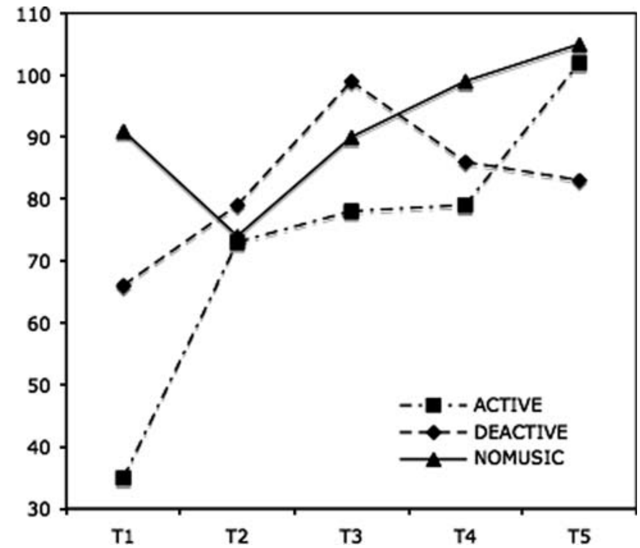

Fig. 1 Global score: Y (score, minimum 0), X (experience, T = trail number)

Autonomic response

The mean heart rate was significantly higher statistically and the heart rate variability was significantly greater for

Table 1 Basic data

	Active ($n = 15$)	Deactive ($n = 15$)	No music ($n = 15$)	p-value
Age: years (range)	33 (25–48)	30 (25–42)	29 (23–37)	0.126
Male gender	7	8	5	0.809
Dexterity (s) (O'Connor test)	96	99	95	0.709
HDT test score				
Right dominant	38.1	36.2	37.6	0.890
Left dominant	4.6	3.1	0.3	0.767
Video games (scale 1–7)	2.0	1.9	2.1	0.691

HDT = handedness dexterity test

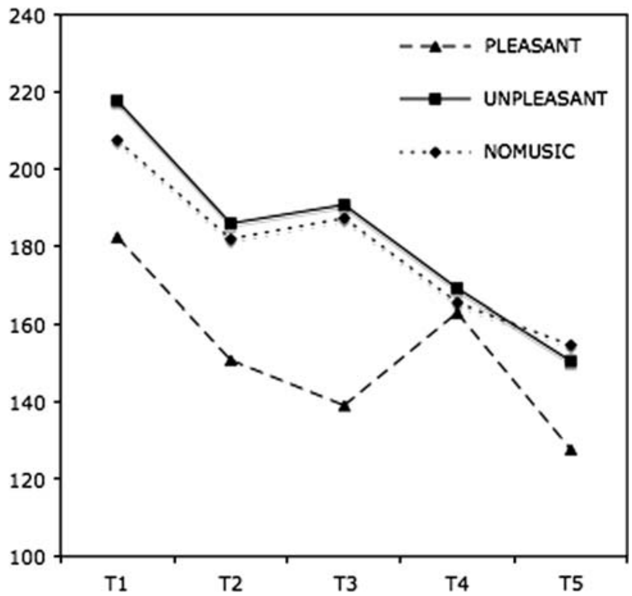

Fig. 2 Relationship between total task time and experience (Y [s], X [experience], T1–T5 [trial number]) between groups considering music pleasant and unpleasant

group 1 (activating music) than for the other two groups. There were significant differences in mean heart rate and heart rate variation between the active group and the other two groups (Table 2).

Discussion and conclusions

This is the first study to examine the influence of activating and deactivating music on the surgical performance of training surgeons in a virtual surgical environment. The main finding of the current experiment is that activating or arousing music did not enhance surgical performance. In fact, we found a trend toward a negative effect, especially in the initial trial. As shown in past studies, we found evidence of a significant learning curve within the first five trials for all three groups [13, 19]. The detrimental effect of activating music was strong during the first trial and accompanied by a significantly increased autonomic response (increased heart rate). However, this effect disappeared completely in the subsequent trials, possibly indicating the ability of the brain to compensate for slight disturbances [14]. When we compared the performance of the participants who experienced the music as pleasant with that of those who felt more uncomfortable with the music, the overall performance was not different.

A previous study by Allen and Blascovich [11], examining possible influences of music on the surgeon, showed slightly different results. Although their study is barely comparable with the current one, they found improved mental arithmetic performance and reduced autonomic reactivity of trained surgeons after they had listened to their favorite music. It should be borne in mind that the participants in their study were well-trained surgeons and dedicated music enthusiasts accustomed to music in the operating theater. Nevertheless, these earlier findings could be taken as evidence that music amplifies concentration and boosts performance.

On the basis of our data, which is more related to surgical practice, we cannot support a strong beneficial effect of music on performance, at least not among novice surgeons. The music we chose for the trial is known to put an individual in an activated or deactivated mental condition. This does not mean that the person listening to this music also likes it. Two individuals can listen to the same track, which is activating their mental condition, but whereas one person can have positive emotions, the other is not at ease with the music. Therefore, we asked the participants about their emotional response to the music. This second analysis led to our finding of a slight, but not statistically significant, tendency for enhanced surgical performance of subjects who considered the music more pleasant, which disappeared with practice.

In our trial, we could show that even music with positive emotional valence does not markedly enforce surgical performance, at least not for novice surgeons in a virtual reality task. We did not find any evidence that activating or deactivating music improves overall manual performance.

The most important conclusion of our study is that music in the operating theater may even have a distracting effect on novice surgeons performing new tasks. This presumption is aggravated by the fact that the novice surgeon usually does not have much influence on the choice of music played in theater. Before starting an operation, the trainee who performs the procedure should be faced with the question whether he or she is at ease with the music chosen. Another approach would be categorically to switch off music during training procedures.

Table 2 Autonomic response of the participants

	Active	Deactive	No music	*p*-value
Mean heart rate (HR): *n* (range)	101 (69–126)	90 (65–108)	89 (66–125)	0.023
HR standard deviation	9	7	6	0.986
Variation (SD*100/HR)	8.5	8	7	0.875
Comparing groups	Active vs. deactive	Active vs. no music	Deactive vs. no music	
Post hoc *p* value (Mann–Whitney *U*)	0.019	0.016	0.68	

We assume that the empowering Mozart effect is only wishful thinking on the part of surgeons. However, future experiments should examine whether experienced and novice surgeons differ in their surgical performance response while listening to musical pieces of different emotional valences. It would be interesting to examine whether experienced surgeons perform differently while listening to music of their choice, preferably in a real operating theater setting. However, the design and interpretation of such a study may be much more difficult.

Conflict of Interest The corresponding author discloses on behalf of all authors any conflict of interest including any financial interests and relationships. There was no sponsoring for this study.

References

1. Wakin D (2006) While in surgery, do you prefer Abba or Verdi? The New York Times. Retrieved 10 June 2006 at http://www.nytimes.com/2006/06/10/arts/music/10doct.html?ex=1307592000&en=b2c79518e16bb962&ei=5088&partner=rssnyt&emc=rss
2. Riley R (2006) The MP3 surgeon and the opera fan. Med J Aust 184:255
3. Rauscher F, Shaw G, Ky K (1993) Music and spatial task performance. Nature 365:611
4. Steele K, Bass K, Crook M (1999) The mystery of the Mozart effect: failure to replicate. Psych Sci 10:366–369
5. Munte T, Altenmuller E, Jancke L (2002) The musician's brain as a model of neuroplasticity. Nat Rev Neurosci 3:473–478
6. Peretz I, Zatorre R (2005) Brain organization for music processing. Annu Rev Psychol 56:89–114
7. Schellenberg E (2001) Music and nonmusical abilities. Ann N Y Acad Sci 930:355–371
8. Zatorre R (2003) Music and the brain. Ann N Y Acad Sci 999:4–14
9. Baumgartner T, Lutz K, Schmidt C, Jancke L (2006) The emotional power of music: how music enhances the feeling of affective pictures. Brain Res 1075:151–164
10. Jancke L (2006) From cognition to action. In: Altenmueller E, Wiesendanger M, Kesselring J (eds) Music, motor control, and the brain, 1st edn. Oxford University Press, New York, pp 25–38
11. Allen K, Blascovich J (1994) Effects of music on cardiovascular reactivity among surgeons. JAMA 272:882–884
12. Sanderson P, Tosh N, Philp S, Rudie J, Watson MO, Russell WJ (2005) The effects of ambient music on simulated anaesthesia monitoring. Anaesthesia 60:1073–1078
13. Rosenthal R, Gantert WA, Scheidegger D, Oertli D (2006) Can skills assessment on a virtual reality trainer predict a surgical trainee's talent in laparoscopic surgery? Surg Endosc 20:1286–90
14. Moorthy K, Munz Y, Undre S, Darzi A (2004) Objective evaluation of the effect of noise on the performance of a complex laparoscopic task. Surgery 136:25–30
15. Hines M, O'Connor J (1926) A measure of finger dexterity. J Pers Res 4:379–382
16. Annett M (1970) A classification of hand preference by association analysis (Annett Handedness Questionnaire). Br J Psychol 61:303–321
17. Hampel R (1977) Adjektiv-Skalen zur Einschätzung der Stimmung (SES). Diagnostica 23:43–60
18. Schijven M, Jakimowicz J (2003) Construct validity: experts and novices performing on the Xitact LS500 laparoscopy simulator. Surg Endosc 17:803–810
19. Schijven M, Jakimowicz J (2004) The learning curve on the Xitact LS500 laparoscopy simulator: profiles and performance. Surg Endosc 18:121–127
20. Aggarwal R, Grantcharov T, Eriksen J, Blirup D, Kristiansen VB, Funch-Jensen P, Darzi A (2006) Evidence-based virtual reality training program for novice laparoscopic surgeons. Ann Surg 244:310–314
21. O'Brien R, Kaiser M (1985) MANOVA method for analyzing repeated measures designs: an extensive primer. Psychol Bull 97:316–333