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The Effect of Music on Robot-Assisted Laparoscopic Surgical Performance

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Abstract

Music is often played in the operating room to increase the surgeon's concentration and to mask noise. It could have a beneficial effect on surgical performance. Ten participants with limited experience with the da Vinci robotic surgical system were recruited to perform two surgical tasks: suture tying and mesh alignment when classical, jazz, hip-hop, and Jamaican music were presented. Kinematics of the instrument tips of the surgical robot and surface electromyography of the subjects were recorded. Results revealed that a significant music effect was found for both tasks with decreased time to task completion (P = .005) and total travel distance (P = .021) as well as reduced muscle activations (P = .016) and increased median muscle frequency (P = .034). Subjects improved their performance significantly when they listened to either hip-hop or Jamaican music. In conclusion, music with high rhythmicity has a beneficial effect on robotic surgical performance. Musical environment may benefit surgical training and make acquisition of surgical skills more efficient.

Keywords

robotic surgery, da Vinci robotic surgical system, surgical skills, kinematics, electromyography

Introduction

Background music has been used in hospitals to calm the patients when they are in the waiting room or before surgery and plastic surgeons use music to distract patient's attention while performing simple outpatient surgical procedures.[1] In the operating room, music creates a warmer, more pleasant environment for both the patients and the staff. It is believed that music provides a diversion, distracting patients from the strange sights and sounds that are common in modern medical treatments.[1]

It is also believed that music has soothing effects. Musical instruments such as harp, lyre, and flute were frequently used to cure the sick and give direction to the healthy.[1] The Egyptians and Greeks acknowledged the value of music in controlling people's moods and physiological responses. Moreover, recent studies show that music is useful for reducing anxiety and pain in patients before and during operation.[2-5] Little attention has been paid to the effect of music on surgical performance in the operating room. However, music is often played in the operating room to increase the surgeon's concentration and to mask noise. Generally, it is indicated that music could have a beneficial effect on surgical performance during delicate procedures.[6-8] Ullmann et al[7] found a positive effect of music on the staff working in the operating room. A total of 63% of these respondents to a questionnaire listened to music on a regular basis in the operating room and stated that music made them more calm and efficient. However, another study by Miskovic et al[8]

examined the effect of music on the surgical performance in novice surgeons in a virtual laparoscopic environment and found no evidence that music improves surgical performance. These inconsistent results demonstrate the need to better establish how music affects surgical performance. In addition, no such study has been conducted with respect to robot-assisted surgery.

In the present study, we investigated how music affected the performance of simple surgical tasks during robotic surgery. We examined if music during practicing with the da Vinci Surgical System (dVSS; Intuitive Surgical, Inc, Sunnyvale, CA) can affect the performance of simple surgical tasks commonly used in robotic laparoscopy. We hypothesized that music would have a beneficial impact on robotic surgical performance. Furthermore, previous research[6] found that surgeons' performance and their physiological responses (eg, blood pressure and heart beats) were influenced by the type of music presented to the surgeons. Therefore, we also hypothesized that the type of music would have a significant impact on robotic surgical performance.

Materials and Methods

Ten medical students (age 26.6 ± 4.1 years) volunteered to participate in this study. All participants had only basic surgical knowledge with no prior experience in robotic surgery. All subjects were right-handed. This study was approved by the Institutional Review Board of the University of Nebraska Medical Center.

All participants performed 2 inanimate surgical tasks using the dVSS: suture tying and mesh alignment (Figure 1). The suture tying task required tying 2 intracorporeal knots with a surgical suture (100 mm long and 0.5 mm in diameter). Subjects tied 3 knots in each trial. Three points 150 mm apart were designated as the sites for tying the knots. The mesh alignment task required the subject to loosen a rolled mesh and accurately align its designated points onto a material platform's designated points. This task required the subject to gently manipulate the mesh and precisely align the mesh on the platform. Subjects had to carefully maneuver and position the flexible material. The subjects performed the tasks by manipulating the dVSS instrument arms from the surgeon's console. Both tasks mimicked actual laparoscopic tasks that required significant dexterity and coordination. Based on our previous research,[9] the mesh alignment task was considered to be more difficult than the suture tying task.

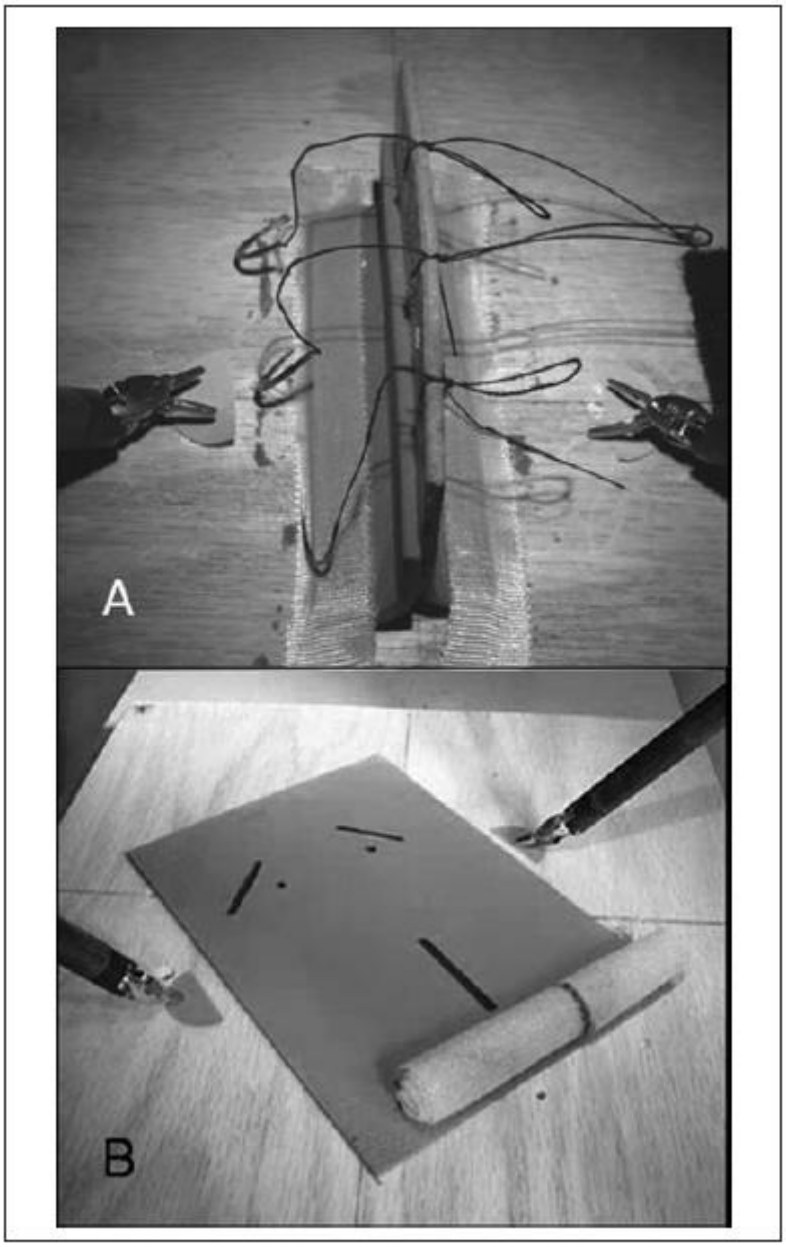

Figure 1. Inanimate surgical tasks: (A) suture tying (ST) and (B) mesh alignment (MA)

Four types of music were selected based on personal communications with surgeons who stated that they commonly heard these types of music in the operating room: jazz, classical, hip-hop, and Jamaican. Same songs were given to all participants for each type of music. The volume was controlled by the participant to the level that they could hear clearly. A condition with no music was included as baseline. All participants were asked to perform 6 blocks of trials in 1 day; both tasks were completed 3 times in each block. The number of trials was based on our pilot work. The experiment began with the condition of no music and subsequently with 4 musical conditions presented in random fashion. It was ended with another block of trials without music. A survey was also given to the subjects to rank their preferences among the 4 types of music at the end of the experiment.

Kinematics of the surgical robot and surface electromyography (EMG) of the dominant arm were recorded from all trials. The kinematic dependent variables used were time to task completion and total distance traveled with respect to the movement of the surgical instrument tips. Both variables were used to differentiate task difficulty in our previous work.[9] They were acquired using the dVSS Application Programmer's Interface provided by Intuitive Surgical, Inc (Sunnyvale, CA). A custom program using LabView

(National Instruments Corp, Austin, TX) was written to interface with the dVSS via an Ethernet connection. Kinematic data was streamed at 100 Hz. All data were postprocessed using MATLAB 6.5 (MathWorks, Inc, Natick, MA).

Surface EMG was used to measure muscle activation of the flexor carpi radialis and extensor digitorum from the dominant arm of each subject. Although many other types of movements (eg, flexion and extension of the thumb, index, and middle fingers, forearm pronation and supination) and thus many other muscles are involved in the performance of the tasks in this study, it has been found that the contribution of the flexor carpi radialis and extensor digitorum in performance of robotic surgical tasks such as suture tying are considerably higher than the other muscles.[10,11] Consequently, these 2 muscles were selected for the present study. A Bagnoli-2 (Delsys Inc, Boston, MA) surface EMG system was used to collect data at 1000 Hz via a custom LabView program. Time domain and frequency domain analyses were performed using MATLAB 6.5 to calculate the mean EMG activation (EMGm) and median EMG frequency (EMGfm), respectively. The EMGm was the average of the normalized EMG output for the entire trial. The EMGfm has been used as an indicator of muscle fatigue.[12] Specifically, a reduction in muscle fatigue is correlated with increased EMGfm. Before the first block of trials, maximum EMG was recorded for both muscles during maximum voluntary isometric contraction for 3 seconds. The total EMG activation volume was normalized by the maximum isometric EMG and then smoothed using a 150-ms root mean square moving window. A complete description of the frequency analysis is given in a previous study.[11]

To determine whether a there was a learning effect for the 2 surgical tasks; a paired *t* test was used to compare the first and the last block of trials with no music for both the kinematics and the EMG measures. Furthermore, to test the 2 hypotheses that we proposed, namely (*a*) music has a beneficial impact on robotic surgical performance and (*b*) the type of music has a significant impact on robotic surgical performance, a 2-way repeated-measures analysis of variance (ANOVA) with music (4 types of music) and tasks (suture tying and mesh alignment) as the within-subject factors was applied to examine the effect of the task difficulty and the effect of music in this study. Post hoc pairwise comparisons with Bonferroni corrections were performed when factors were significant. The significance level was set at $\alpha = .05$. All data are presented as mean ± standard errors.

Results

There were no significant differences between the first and the last block of trials without music for any parameter. This indicated that no learning effect occurred for the two surgical tasks in our protocol. Therefore only the first block of data was used as the baseline control condition.

Our results also confirmed that mesh alignment was significantly different from suture tying in both kinematic variables ($P < .001$). The mesh alignment task took a longer time to complete than the suture tying task (Figure 2). The total distance traveled by the instrument tips was also longer for the mesh alignment task (Figure 3). Our data indicated that the mesh alignment task had higher EMG activation volume for the flexor carpi radialis ($P < .001$) and extensor digitorum ($P = .001$) muscles when compared with the suture tying task. No differences were found in the EMGfm between the 2 tasks.

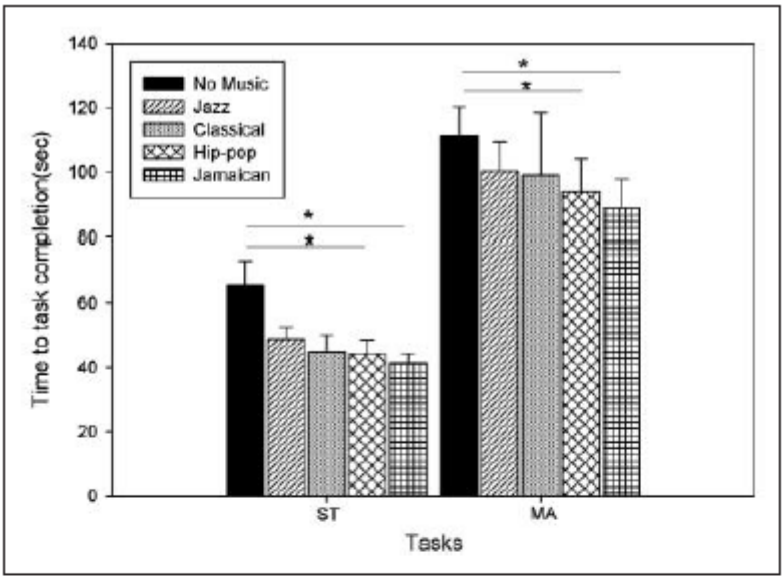

Figure 2. The time of task completion of the 2 surgical tasks (suture tying [ST] and mesh alignment [MA]) performed in the 4 different musical environments

The time to task completion was significantly shorter in the hip-hop and Jamaican music environments as compared with no music (*$P < .05$).

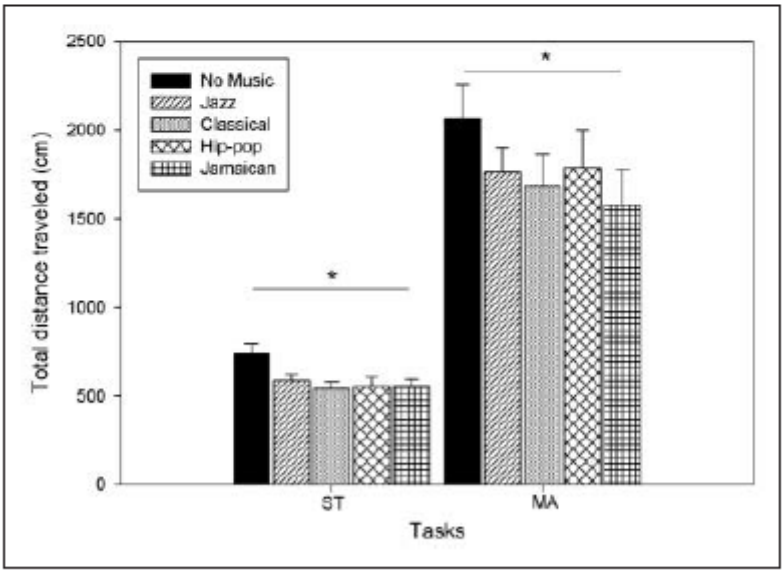

Figure 3. The total travel distance for the 2 surgical tasks (suture tying [ST] and mesh alignment [MA]) performed in the 4 different musical environments

The total travel distance was significantly shorter in the Jamaican musical environment as compared with no music (*$P < .05$).

Significant music effects were found for both the time of task completion ($P = .005$; Figure 2) and the total distance traveled ($P = .021$; Figure 3) for both tasks. For the time of task completion, the follow-up pairwise comparisons indicated that all subjects performed both tasks significantly faster when they listened to hip-hop ($P = .036$) and Jamaican music ($P = .001$) in comparison to no music. For the total distance traveled, the follow-up pairwise comparisons indicated that all participants completed both tasks in the shortest distance when they listened to the Jamaican music ($P = .038$).

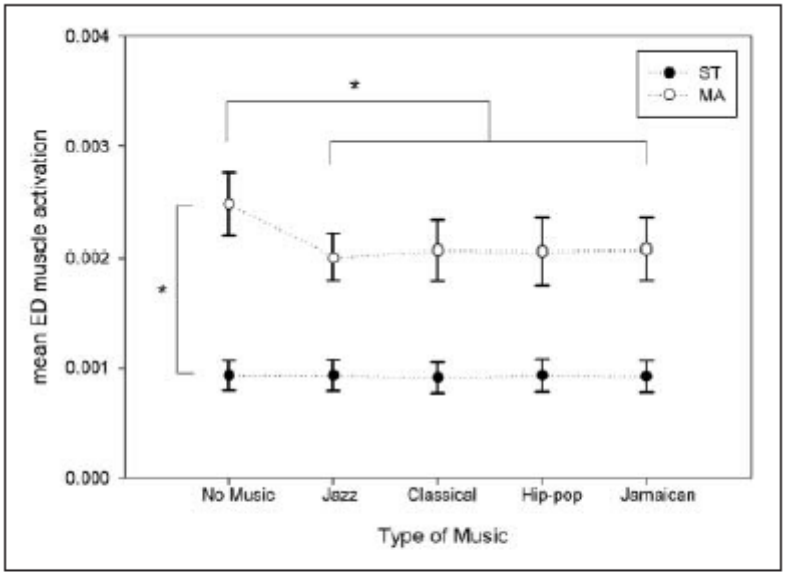

Figure 4. Mean electromyography activation (EMGm) of the extensor digitorum (ED) muscle for the 2 surgical tasks (suture tying [ST] and mesh alignment [MA]) performed in the no music and 4 different musical environments
A significant noise effect was found as indicated by a smaller EMGm for the 2 surgical tasks in the presence of music (*$P < .05$).

Significant music effects were also found for both the EMGm ($P = .016$) and the EMGfm ($P = .034$). A significant interaction was found for the EMGm of the extensor digitorum muscle ($P = .028$; Figure 4). The EMGm was significantly reduced ($p < 0.001$) when the difficult task (mesh alignment) was performed with any kind of music (Figure 4). In contrast, no differences were found in the EMGm when the suture tying was performed with music. Our results did not find any differences in the flexor carpi radialis muscle for the EMGm. For the EMGfm, a significant music effect was found in flexor carpi radialis muscle ($P = .040$). Particularly, the value of EMGfm was significantly increased when participants listened to the hip-hop and performed both surgical tasks ($P = .040$; Figure 5). No differences were found in the extensor digitorum muscle for the EMGfm.

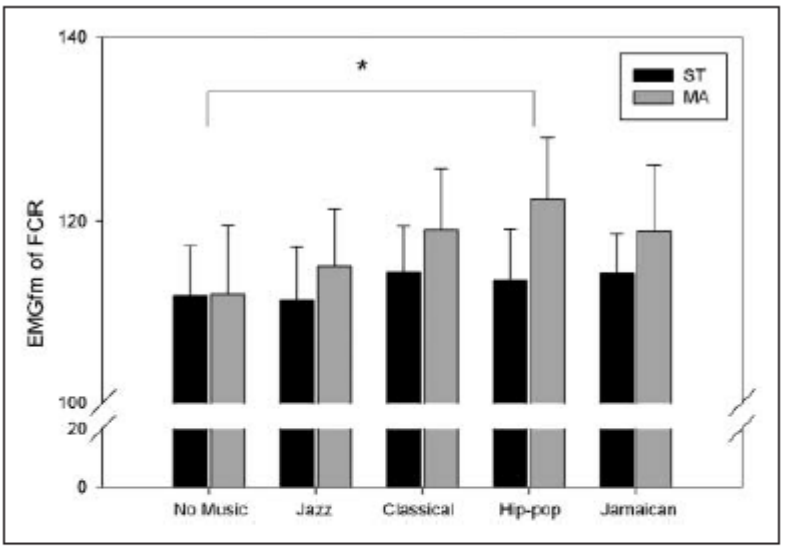

Figure 5. Median electromyography frequency (EMGfm) of the flexor carpi radialis (FCR) muscle for the 2 surgical tasks (suture tying [ST] and mesh alignment [MA]) performed in the no music and 4 different musical environments
A significant noise effect was found as indicated by an increased EMGfm was required for the 2 surgical tasks with the presence of hip-hop music (*$P < .05$).

Discussion

The purpose of this study was to investigate how music affected performance of simple surgical tasks during robotic surgery. We hypothesized that music would have a beneficial impact on robotic surgical performance. Furthermore, previous research6 found that the performance of surgeons and their physiological responses (eg, blood pressure and heart beats) were influenced by the type of music presented to the surgeons. Therefore, we also hypothesized that the type of music would have a significant impact on robotic surgical performance.

Our results supported our first hypothesis that music affects performance of simple surgical tasks during robotic surgery. All participants performed the surgical task more efficiently (reduced the time to task completion and total distance traveled) while listening to music. These results were in line with other studies that have shown that music in the operating room can reduce stress and make physicians and nurses calmer and improve the surgeon's efficiency.[7] It has been documented that music in the operating room provides a warmer and pleasant environment for both patients and medical staff. Such a soothing environment has been found to provide a positive effect in the stressful operating room.[1] A previous study has also found that music could reduce cardiovascular activity among surgeons and improve speed and accuracy of task performance.[6] Our work further supported these previous findings and indicated that this was also the case for robot-assisted laparoscopy. Our data revealed a significant decrease in the averaged muscle activation and an increase in the median muscle frequency when the music was presented. These EMG results indicated that participants required less muscle effort that led to reduced muscle fatigue when they performed robotic laparoscopic training tasks in the presence of music. Muscle fatigue has been associated with surgical performance[11]; reduced muscle fatigue could lead to a better performance in laparoscopic surgery.

The above results are in disagreement with those from Miskovic et al[8] who found that laparoscopic performance in virtual reality was not affected by music. It is possible that their methodology using virtual reality to examine the effect of music on surgical performance was different from an actual environment. Moreover, the type of music used in the study from Miskovic et al[8] was limited to 2 kinds (pleasant and unpleasant) with no other descriptions given. In our study, all subjects listened to more than 2 types of music, which provided more conditions to test our hypotheses. Despite the inconsistent findings between our study and Miskovic et al,[8] conventional laparoscopic surgery is distinctly different from robot-assisted surgery.[13,14]

Robotic surgery may actually produce an environment that is more susceptible to sounds because of the additional movements of the surgical instrument arms or occasional alarms from the system.

Our results also supported our second hypothesis that the effect of noise on robotic surgery may be driven by the type of music. We found that the time to task completion (Figure 2) and the total distance traveled (Figure 3) was reduced significantly when subjects performed surgical tasks and listened to either hip-hop or Jamaican music. Our results further showed that the averaged muscle activation reduced in the presence of music. In particular, an increase of median EMG frequency as an indication of reduced muscle fatigue was found when subjects performed tasks and listened to hip-hop music only. It is possible that robot-assisted surgical performance can be enhanced by the presence of music with high rhythmicity (eg, hip-hop or Jamaican), which provide a tempo to keep up the speed of the performance. Interestingly, 7 out of 10 participants rated that hip-hop was one of the top two favorite types of music. It provided additional evidence to support the idea that not all music was beneficial, but only subject-preferred music had a larger impact on the surgical performance. This was shown in a previous study by Allen and Blascovich[6] that task performance among surgeons was significantly better in the surgeon-selected music environment than in the experimenter-selected music environment.

It is worth noting that the impact of music on robotic surgical performance may be driven not only by the type of music but also by the level of task difficulty. More challenging and complex tasks, such as mesh alignment, may show a larger effect of music on surgical performance. Our data revealed that only performing complex surgical tasks (mesh alignment) with music results in the reduction of averaged muscle activation (Figure 4). Further investigations are required to confirm this result. It is also noted that the learning effect was not significantly revealed in our study, whereas previous works[10,11] demonstrated that surgical task repetition alone increases performance. The differences between our study and previous data may be because of the training environment. Although participants in this study performed the same surgical task 3 times in each block, the implementation of music in the working environment may alter the learning process differently in each participant physiologically[6] and even emotionally.[1] Perhaps the learning effect will appear or even be enhanced when participants performed the training only with one type of music, especially the one they prefer.

One of the limitations of this study is that the whole experiment was not performed during an actual operation. The type of participants recruited in this study may also not represent the general medical population. All participants were young medical students who may mostly prefer music with high rhythmicity. The effect of music on robotic surgical performance may differ in experienced surgeons who are in their 40s and 50s. Nonetheless, this work is the first study to examine the effect of music on robot-assisted laparoscopic surgery. It provides the foundation for future studies to investigate the relationship between training and background music during robot-assisted and laparoscopic surgery. More investigations are required to confirm which types of music or even which types of sounds (eg, background noise) will affect robotic surgical performance in experienced surgeons and the actual operating room. Training in a musical environment may also influence skill acquisition and tissue handling in robot-assisted laparoscopic surgery. More studies are necessary to confirm this hypothesis and possibly incorporate music into robotic surgical training.

Conclusions

Our findings demonstrated that the implementation of music improved robotic surgical performance. However, the impact of music on robotic surgery depended on the type of music. Therefore, it is useful to consider incorporating subject-preferred music into future robotic training programs.

Authors' Note

This study was presented in poster format at the Neuroscience 38th Annual Meeting, Washington, DC, November, 2008.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

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