Group 05

Effect of Music on Perceived Arm Fatigue during Mid-air Gestures

Authors

Nivedhitha Asokkumar

Svenja Westphal

Yash Joshi

Motivation

Reasons for examining the effect of music on arm fatigue.

- Mid-air arm gestures are becoming increasingly popular.
- Users have arm fatigue while performing mid-air gestures which can lead to Gorilla-Arm.
- Easing this fatigue is important for the well-being of user.
- Music has proven to reduce fatigue in other domains.

Research Question

When performing mid-air arm gestures, does headphone music have an effect on the perceived arm-fatigue level?

Hypothesis

Listening to headphone music while performing mid-air arm gestures reduces the perceived arm fatigue level.

Experiment

Apparatus

- Task sheets A2 size on vertical flat surface.
- OnePlus 5 with flashlight on taped to a belt, secured to the user’s chest.
- Phone connected to headphones (JBL TUNE510BT) to play music.

Task

- The hand casted a shadow on the task sheet due to the light source on the chest of participants.
- Each task sheet had movements that corresponded to numbers which forms a task.
- These movements were to be completed serially based on these numbers.

Experiment

Design - Within Groups

10 Participants

X 4 Task Types (Motion Path Description, Object Resize, Object Rotation, Topology Change)

X 2 Music Condition (With Music, Without Music)

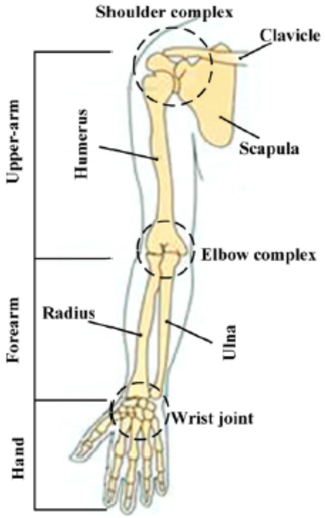
X 2 Repetitions

= 160 Trials

Data Analysis

Data collection

- Participants reported the fatigue level in three regions of the arm.
  i. Upper Arm
  ii. Lower Arm/Forearm
  iii. Hand
- Data collected after each trial based on the BorgCR10 Scale with Verbal Anchoring.
- The data was collected with and without music.



[a]The human upper limb anatomy structure

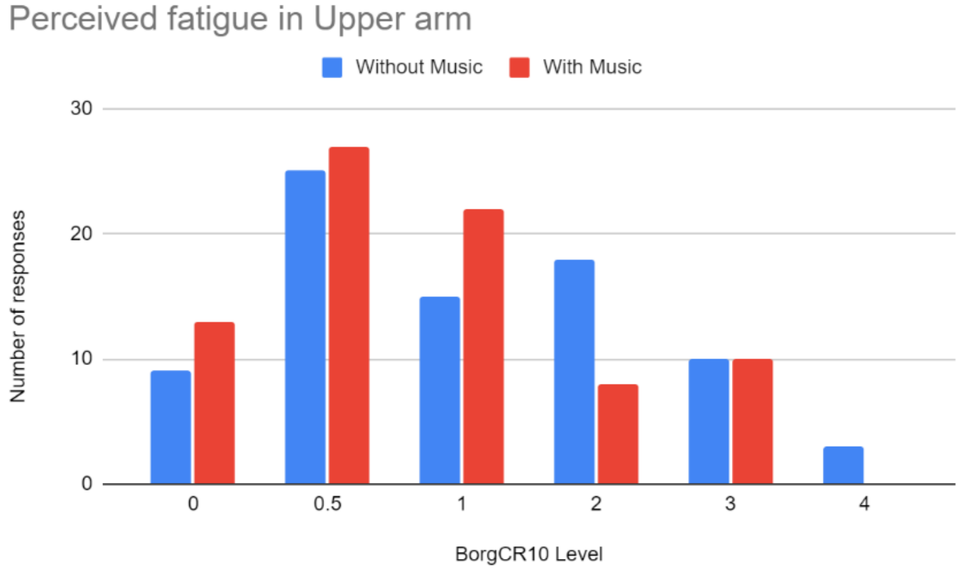
Score	Definition	Note
0	Nothing At All	No arm fatigue
0.5	Very, Very Weak	Just noticeable
1	Very Weak	As taking a short walk
2	Weak	Light
3	Moderate	Somewhat but Not Hard to Go on
4	Somewhat Heavy	
5	Heavy	Tiring, Not Terribly Hard to Go on
6		
7	Very Strong	Strenuous. Really Push Hard to Go on
8		
9		
10	Extremely Strong	Extremely strenuous. Worst ever experienced

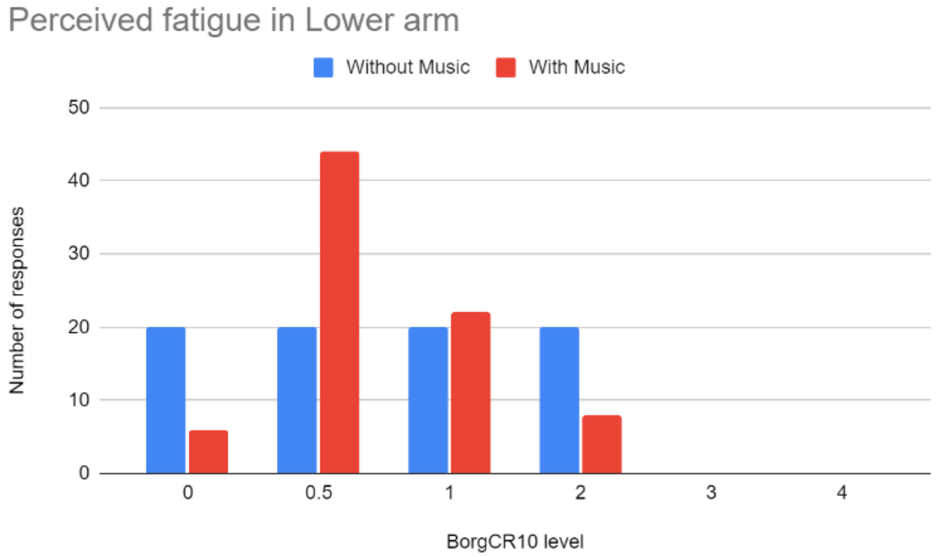
[b]Borg CR10 Scale with Verbal Anchoring

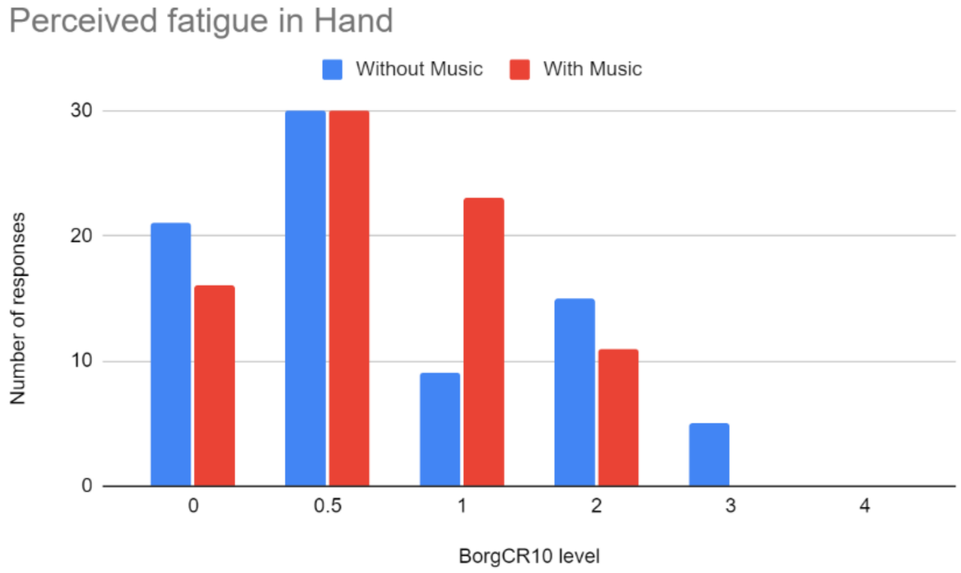
Image adapted from
a) Chen et. al. Design of a 6-DOF upper limb rehabilitation exoskeleton with parallel actuated joints
b) Jang et. al. Modeling Cumulative Arm Fatigue in Mid-Air Interaction based on Perceived Exertion and Kinetics of Arm Motion.

Data Analysis

- Shapiro-Wilk test shows that the data collected was not Normally Distributed.
- We performed Wilcoxon Signed-Rank Test for each of the Arm Regions for different Music Conditions.







Data Analysis

- Findings from Wilcoxon Signed-Rank Test for each of the Arm Regions for different Music Conditions.
  i. **Upper Arm** - Music Condition had a significant effect on perceived arm fatigue, $p = 0.00048$. The perceived arm fatigue With Music (M = 1.019, 95% CI [0.812 1.225]) was lower than Without Music (M = 1.319 95% CI [1.078 1.559])
  ii. **Hand** - Music Condition had a significant effect on perceived arm fatigue, $p = 0.0041$. The perceived arm fatigue With Music (M = 0.75, 95% CI [0.614 0.886]) was lower than Without Music (M = 0.86 95% CI [0.665 1.06])
  iii. **Lower Arm** - Music Condition had a significant effect on perceived arm fatigue, $p = 0.08$.

Discussion

Recommendation

- While designing Gesture Based Systems, music can lower the perceived arm fatigue thereby improving user’s well being.

Limitations

- Use of shadow based technique instead of an actual Gesture Based System.
- Tested only limited set of Gestures.
- Tested only on limited number of participants.