The Power of Music - How environmental variables can disrupt or enable productivity

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***Abstract*—How does music affect a developer? This study will explore how music affects our productivity based on several factors such as tempo and presence of lyrics. The study shows that choosing appropriate music can have a stimulating effect if played in the right circumstance. The variations of music tested in the study is comprised of various tempo, with and without lyrics as well as different genres. Music was chosen in such a way as to attempt to facilitate and disrupt productivity at various points in order to fully explore the implications on music playing during software development. Previous work show scattered results and varying relevance to the topic of software development, with inconclusive results and uncontrolled or overly simplified variables. By gathering data via triangulation using questionnaires, interviews and observational studies we found arguments to support the statement that music can be a facilitator to productivity if used correctly.**

I. Introduction

Music has become a centralized part of our everyday life, ever present wherever we may go. Some state that listening to music facilitates their productivity during work, while a significant number of companies disallow music at the workplace citing it as an inhibiting factor. The subject is particularly divisive in the software engineering field where various survey based articles state that evidence on the effect on productivity is inconclusive or subjective. While it is fairly obvious that noises that are disruptive, loud and hard to control such as when working in proximity to a building site or an overly talkative co-worker reminiscing on what happened at the company party last weekend the value of playing music to drown out or disperse the effect of such noise should be considered. While a study of machine operators in the garment industry of Sri Lanka [1] found that listening to music during work increased productivity and work performance there is also opposition to the idea in a study covering reading comprehension [2] where introverts where found to be significantly negatively affected which could potentially be related to code comprehension. Studies targeting software engineers such as *The Sound of Software Development: Music Listening Among Software Engineers* [3] are purely based upon surveys, which are based on reflection upon a workers own experiences. As a result of previous sources with scattered and inconclusive results and focus groups from non-software development environments we pose the following research questions.

- Does the tempo of the music played affect productivity during software development?
- Does the impact of music vary depending on the presence of lyrics?

II. Background

This section will highlight and discuss some previous work on the subject of music listening during work, specifically divided into two categories of relevancy and how these various forms of previous research relates to the study.

While some studies, such as the *Sri Lanka study* [1], specifically test the effect of music during work they focus on more monotonous tasks not necessarily related to software development. In the case of the Sri Lanka study the focus group consisted of workers at a facility in the garment sector, which consisted of repetitions of a specific task as opposed to the constantly changing problems encountered when developing new software.

Another study, *Music While You Work: The Differential Distraction of Background Music on the Cognitive Test Performance of Introverts and Extraverts* by A. Furnham and A. Bradley [2] focuses on music listening during recall and reading comprehension tests in silence or while listening to Hip-hop. Both tasks could be considered sub-tasks of software development, either as recalling information from previous coding sessions or simply comprehension of code being read. The study does not consider the presence or absence of vocal components, nor does it test music with varying tempo which has been explored in this study.

In the paper *The Sound of Software Development: Music Listening Among Software Engineers* [3] thousands of developers partook in two separate surveys, which is a more closely related subject as compared to sources cited above. It is stated that evidence of whether music inhibits or facilitates productivity is inconclusive, albeit it is stated that the two have correlation. It states that the effect is dependant on the context of when music is played, typically it is used to block out currently disturbing sound in the working environment. In a sense this coincides with T. Lesiuks conclusion that time-on-task is longer but quality is unaffected when listening to music in *The effect of music listening on work performance* [4], which could be related if music is to be considered a constant and predictable environmental variable. Another interesting

factor to consider is that T. Lesiuk found that time spent on tasks increased and quality of work declined when music was not played, stating that the removal of such stimuli is directly disruptive while the benefits of music increased over time with a probable diminishing effect.

III. Method

This section will reflect over the methods that where used to conduct this in depth study. Furthermore we will present our environmental variables that could have had an effect on our outcome.

A. Objective

As stated in the introduction, previous studies are somewhat old and scattered. The objective of this study is to hopefully find a connection between music and the productivity of software developers. Playing heartbeat music and rock music as a study doesn't quite reflect upon real world scenarios, neither does playing hiphop and taking memory tests. [5] Therefore we think that this study is interesting since we will look at modern parameters such as music with and without lyrics and the effect of different paced music. The purpose of these parameters are to find correlations between productivity, stress and the ability to focus during software development such that we can explore the implications of music with certain traits and its effect on software developers.

B. Tools and Environment

This study was conducted alongside the course EDAF45 - Programvarutveckling i grupp (PVG) At Lund's University which is a mandatory course for second year students. In the course the students are suppose to develop a program during 6 weeks and the course consists of 6 Mondays long labs(8-17 o'clock) that were dedicated to developing and planning games on Wednesdays for 2 hours. The study was carried out on Mondays when the whole team sat together in a computer hall at school with the exception for those who felt sick or had COVID-symptoms whom participated online.

The computer hall was located in the basement with no windows facing outside. The speaker used was a *SOUNDBOKS (Gen. 3)* connected to a laptop playing music. Some of the music playlist that were used can be found in appendix Music (clickable links).

The group project was centered around the use of the agile eXtreme-Programming methodology in a group of 9 students, developing a program for time-tracking enduro races of varying formats. The acting customer for the project was a faculty employee with significant experience in software development projects.

C. Questionnaires

At the end of every sprint session a questionnaire get sent out to the team members. This questionnaire contains a wide spectrum of questions which are used to get quantitative data. The questionnaires were answered anonymously to increase the the chances of getting negative inputs as well. All questions that where asked in the questionnaire can be found in appendix Questionnaire. In an effort to detect changing trends in questionnaires some questions were recurring every week, whilst others only appeared a single time when interesting observations had been made during a given sprint.

D. Observations

During the sprints we took notes of observations of the team whenever we identified anything interesting. This is valuable when triangulating data gathered whenever inconsistencies between questionnaires and interview would be detected. Observations were also used to provide some background to the discussion of validity whenever interference arose during a given sprint.

E. Interviews

Interviews were conducted on a focus group represented by 5 out of 9 members at the last sprint. The questions asked can be found in appendix Interview. Interviews were conducted in a more discussion-centric fashion, with follow-up questions thought of on the spot frequently used. This enabled further elaboration upon points of interest, allowing for more information to be elicited from the interviews. However, this can lead to providing some direction for what answers were expected from the interviewees.

IV. Results

This section will present all the data we have gathered during the last 6 weeks. The section will be divided into our two research questions with results gathered from all our forms of data gathering.

A. Does the tempo of the music played affect productivity?

In the focus interview group it became clear that music effects everyone differently. A few students said that music doesn't affect them at all and that after a few weeks they didn't really think about the music anymore. A few students however said that music helps them become more productive in different ways. Some said that it help block out distracting sounds so they can concentrate while some said that faced paced music made them more productive. The same student said at the same time that they felt more stressed at the same time. In the study *Effect of music tempo on task performance by Mayfield and Moss* they could see the same pattern for the ones listening to rock music. [5] This could also be seen in the questionnaires where majority of the students answered that it helped them concentrate and that some students felt even more stressed when the fast paced music played during release. As coaches we could even observe how the stress levels increased when the volume and pace changed during the release. There was even a student who said: "This music is making me more stressed".

B. Does the impact of music vary depending on the presence of lyrics?

The questions asked during interviews and questionnaires related to this research question varied greatly, with questionnaires stating that the presence of lyrics or vocal components in music had an insignificant effect whilst a majority of interviews concluded that it did have an effect particularly when a song played is recognized. It was stated in interviews that the presence of music was disruptive when subjects felt that they wished to sing along or otherwise allow for the song being played to overtake development as their main focus. Such behavior was not noted when listening to music lacking lyrics.

The observations made during long labs support the statements from interviews, with several recorded instances of students choosing to sing along to more popular songs rather than keep developing. The effect was particularly strong when songs that had significance to multiple subjects were played, such as music that multiple subjects knew the lyrics of. Again, music which did not feature lyrics lacked such an effect.

C. Trends

When looking at the trends of two specific questions some trends were able to be identified, particularly when the choice of music clashed with the expected mood or tempo of the team. These questions are *How did you experience having music in the background while working?* and *Was it distracting when the song had lyrics?* When the music chosen was the Lo-Fi beats playlist the average answer to the former question was 3.67, 3.55 when tempo shifted from low high during the course of the sprint, 3.1 when tempo was shifted from high to low as well as when the team chose music on their own. These questionnaire results were consistent with what the team members answered during interviews, stating the smooth jazz segment during the last hour before a release as jarring.

V. Discussion

In this section we will discuss the findings that where made during the project, furthermore we will reflect over the validity and how related work can be applied on our study. At last we will discuss how future work can be done and how our study can be used as a base to further analyze music in the work environment.

A. Validity

The first and major problem that we can find with our study is the duration and the amount of people that have been involved in the study. The study was conducted during a span of 6 weeks and involved 9 team members. A longer period would be desirable since it would further strengthen the validity of the project.

We made sure not to provide specific answers or hints regarding the study in an attempt to lessen the impact of confirmation bias, despite the general area of study being fairly obvious as a result of the study setting. This does lead to some potential changes in behaviour in the team as a response to knowing that they are being observed and what the general topic of the study being conducted is.

Another point of interest is the study being subjective in nature, though we did triangulate our information gathering the ratings used in questionnaires for instance are based on individual experiences and each individuals expected level of confirmation with specific numbers. The number four on a point scale has the same value in gathered results but not in the eyes of the various subjects whom provided answers. This was somewhat displaced by repeated instances of the same question to detect trends over the study's life cycle but should still be considered.

The study can be considered applicable to tasks that are of comparable complexity to software development. If studies such as *The effect of music listening on work performance* [4] are also considered we can derive that tasks of a higher cognitive complexity requires more careful consideration on the choice of music for it to facilitate productivity, whereas simpler tasks are less affected. It is important to consider the mood of whomever is to listen to the music chosen while performing a specific task, as opposing messages will be detrimental to productivity.

B. Related work

One of the first studies we found was *Effect Of Music Tempo On Task Performance* [5]. As stated earlier in the report we found this very interesting since we wanted to research the same area. However we quickly realized that the study was old and did not focus on software development. Therefore we decided to use the study as a reference for our in-depth study. Furthermore we saw many correlations in our study that reflected parts of their findings.

As we wanted to study the effects of lyrics and their role as a distracting factor. We sought out to find studies that covered this aspect. The study *Music While You Work: The Differential Distraction of Background Music on the Cognitive Test Performance of Introverts and Extraverts* [2] studied how pop-music affected cognitive test performance. The problem that arose here was that the study was conducted on a memory exercise. The big difference between memorizing and code development is that you dont need the same focus to try to remember what to write. Our hypothesis was that introverts were more distracted by pop-music/music with lyrics compared to the extroverts.

Another article found that was really interesting: *The Effect Of Music Listening On Work Performance: A Case Study Of Sri Lanka* [1]. This article had a few very interesting research questions that is closely related to our study. As we wanted to research the same aspects on software development we found this study somewhat helpful.

C. Future work

This study chose to restrict the scope of the study to two research questions which can be expanded upon. During the final stages in the course of data gathering, particularly the final hours of development when no music was played, some interesting behaviour was noticed that related to but was not part of the study scope. Students were more susceptible to outside disturbances such as people walking by windows or overhearing what other programming pairs were discussing, possibly due to the sudden lack of stimuli as recognized by T. Lesiuk in *The effect of music listening on work performance* [4]. Perhaps the brain attempts to find other stimuli to replace music or subjects are more susceptible to peripheral information, if music can improve time-on-task then the sudden lack thereof might raise the risk of uncontrolled changes in the working environment disrupting developers ability to focus. This touches upon the topic of cognitive load, which has been discussed in articles such as *The Influence of Background Music on Learning in the Light of Different Theoretical Perspectives and the Role of Working Memory Capacity* [6].

The consistency of stimuli and reduction of disruptive environmental changes appear to have significant effects, but it is not quite known to which extent although as the trends subsection of the results section states there is a noticeable effect when music that opposes the teams expected mood is playing. Future work could also, for instance, test subjects ability to solve the exact same programming problem with various forms of music or total silence. Many universities have programming exam elements testing code reading comprehension and it would be interesting if such a study would be consistent with the findings in *Music While You Work: The Differential Distraction of Background Music on the Cognitive Test Performance of Introverts and Extraverts* [2] as well.

VI. Conclusions

It appears the answer to both of the study research questions is yes, which directly means that the choice of music played can have a varying level of positive or negative effect on productivity.

If we follow the conclusion from *The Sound of Software Development: Music Listening Among Software Engineers* [3] stating that music listening and productivity is correlated, and combine them with conclusions *The effect of music listening on work performance* [4] and the results of this study we can say that lyrics should not be present if the goal is to maximize productivity. Beyond lyrics, the music should reflect the mental state of a user such that they are not overly stimulated nor under-stimulated as found in both questionnaire answers and interviews. This implies that music should not entice developers to start dancing mid-sprint nor should smooth jazz at 40 beats per minute be used in an attempt to calm developers when nearing a release, which may sound obvious but should be considered extremes. Playing overly hectic music ahead of a release might improve the pace at which developers work, but if we consider the results *Effect Of Music Tempo On Task Performance* it will also decrease the quality of their work and increase levels of stress. Similar to other forms of stimuli such as coffee, overstimulation yields jittery unconcentrated developers whilst a complete lack of such stimuli causes developers to be prone to fatigue and susceptible to distractions.

Appendix Questionnaire Questions

Questions that we asked:

- Gender
- Age
- Which program are you studying
  - Computer science
  - Communication science
- Do you see yourself as:
  - Introverted
  - Extroverted
- Are you distracted by sound when working?
- What is your favorite music genre?
- Did you feel confused at any time during today's sprint?
- What was the hardest thing today?
- How did it go with version control / GIT?
- I promise that I did TDD today
- Do you listen to music while studying?
- Were you stressed at any time during todays sprint? If yes, when?
- Was it distracting when the song had lyrics?
- What music did you prefer?
- How did you experience having music in the background while working?
- Are you annoyed with sounds while working?
- Was the volume too loud today?
- Did you have a moment where the music had a more distracting effect rather than a helping effect?
- How did you feel prior to the release today?
- Did it have a big effect that the coaches were attending online?
- What do you think we wanted to research today?
- I have started to enjoy music more during the sprints
- I have started to like GIT
- Do you feel that the tempo of the music had an effect on your productivity? How?
- What do you think the music played today was meant to study?
- What do you think of white noise instead of music? motivate your answer.
- During the second half of today's sprint, very calming music and white noise was, how did you perceive your energy levels during the second half compared to previous sprints?

Appendix Interview Questions

- How much do you listen to music?
- Do you listen to music while:
  - Working out? If yes, why?
  - Studying? If yes, why?
- So in which occasions do you listen to music?
- Do you think the music should have lyrics or not?
- Do you have the same standpoint when studying? if they say lyrics we asked if they believe that it could disturb their ability to learn.
- What type of music have you liked the most during the sprints?
- How did it feel when there was no music during a sprint? (first iteration and final 2 hours of the last sprint)
- Did the music stress you at any point? when?
- Did the music have a calming effect at any point? When?
- During two sprints we specifically analyzed if tempo could effect the student, did you notice this?
- During one sprint we gradually increased the tempo from 8 o'clock to 5 o'clock and vice versa. Did you notice this?
- Do you think you would have been more distracted if you could queue the music?

Appendix Music Playlists Used

- Lo-Fi
- Jazz
- 40 bpm
- 80 BPM
- 100 BPM
- 120 BPM
- 140 BPM
- 160 BPM
- 180 BPM
- 200 BPM
- Fast-paced
- Stressful release music
- Break beats

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