Tutored Project Report

The exploitation of physiological and behavioral data for music discovery.

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Acknowledgement

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Abstract

Music discovery is the process of appreciating musical tracks with which the listener is not familiar with. Music discovery can be influenced by multiple factors, that we can group in two categories. The first category is music-related factors such as rhythm. The second category includes listener-related factors such as stress, relaxation, emotion, mental effort, familiarity, and uncertainty of appreciation. The aim of this research is to understand the factors that influence music discovery. In order to answer this question, we will divide it into 4 research questions. The first two questions are based on mental effort. They aim at knowing whether we are more likely to know if we like a musical track or not when we allocate more mental effort to music discovery, and if we know quicker whether we like a musical track or not when we allocate more mental effort to music discovery. The third research question is related to relaxation and aims at knowing if we know quicker that we like a musical track or not when we are relaxed. Finally, our fourth research question is based on emotions and aims at knowing if the process of music discovery is also influenced by emotions that are close to “Relaxation” in Russel’s Circumplex Model. To do so, we designed a 2-session experiment. We created a playlist for each participant based on their musical preferences. During the first and the second session, the participants had to listen to unfamiliar musical tracks while we measured physiological responses through objective means. At the end of each musical track, they had to rate them according to their liking and familiarity judgment so that we could gather some subjective data. The results obtained allowed us to generate a correlation matrix showing some strong correlations and significant results. Amongst the many results, there is a significant effect of mental effort on music discovery. Moreover, the correlation matrix shows no correlation between subjective measures of relaxation between session 1 and session 2. However, regarding emotions, it is possible to say that participants' self-reported emotions are consistent with the objective measures. We can interpret these results for the three variables studied: mental effort, emotions and relaxation. However, we can’t make any more conclusions since further data analysis might be needed.

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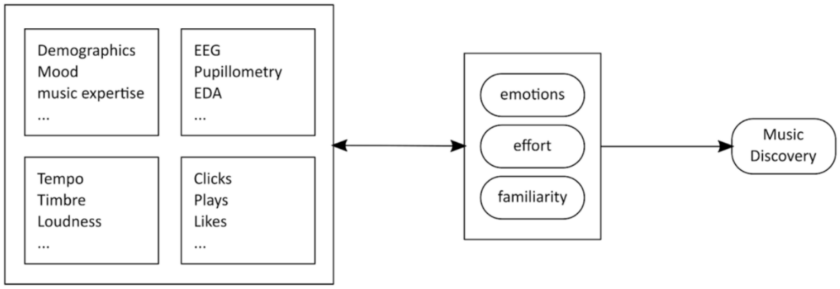
1. Introduction

This second report is part of a first-year master's tutored project. Our subject was the following: **The exploitation of physiological and behavioral data for music discovery.** In this report we will discuss the place and the links of the different factors that can influence music discovery. Following experimentation, we will interpret our results and then conclude.

1.1 Context of the GRIEEEG Project



GRIEEEG project dimension diagram

This tutored project is part of the GRIEEEG project (German Recommendations using Information from eye trackers and EEG), which is a bilateral collaboration between France and Norway, and involves researchers in computer science, psychology, and clinical neuroscience. Our subject was the following: **the exploitation of physiological and behavioral data for music discovery.**

The researchers want to create a recommender system that takes into account these four dimensions (appreciation, mental effort, familiarity and emotion) to help music discovery. We can see that physiological (EDA, EEG, etc.) and behavioral (clicks, play, etc.) data would be linked to these dimensions, which are themselves linked to music discovery. Several factors are taken into account before or during music discovery. Our project is a first step towards this goal. Our contribution to these studies was to formulate an experimental protocol, which made it possible to corroborate the results obtained during previous studies and to use our results to better understand the process of music discovery through these different factors.

1.2 Objectives of the tutored project

For this experimental protocol, we will ask ourselves the following question: *what human factors influence music discovery?*
More precisely, how does each human factor, such as mental effort, emotions or relaxation, influence music discovery?

2. Related work

While reviewing the related literature, we were especially interested in the influence of rhythm on music discovery, the influence of relaxation on music discovery as well as the influence of mental effort on music discovery. However, in the context of the experimental protocol, we will only focus on mental effort, emotions, and relaxation.

2.1 Defining music discovery and the factors influencing it

In general, several factors can influence the music discovery process, which we propose to categorize in two categories: music-related factors and listener-related factors. Music-related factors include the rhythm. We know thanks to certain studies that rhythm has the ability to make the listener move in rhythm (or not) with the musical track he perceives. (Burger, Thompson, Luck, Saarikallio, & Toiviainen, 2013). The rhythm of a musical track can also influence sports productivity (Kim, Aiello, & Quercia, 2020). Knowing the complexity of this aspect, we decided to focus our study on the second aspect of the process of music discovery: listener-related factors. Listener-related factors include psychophysiological characteristics of the listener. We are particularly interested in relaxation, emotion, and mental effort because they play a significant part in an individual's willingness and ability to commit to music discovery. Additionally, we will investigate as a side question the evolution of familiarity during music discovery. According to (Joel, 2022) music enables decreased physiological arousal meaning reduced stress-level. Moreover, relaxation allows individuals to increase mind receptivity and fully benefit from music discovery whereas stress prevents individuals from concentrating and engaging with music discovery due to mental overload. According to Kim (Kim, Aiello, & Quercia, 2020) emotion or mood can be regulated by the music, in return, there is no research about the influence between music and music discovery.

Regarding the evolution of familiarity and uncertainty of appreciation during music discovery, studies (Pereira, et al., 2011) tend to suggest that these two factors vary according to each person and each music, and that repeated listening to one musical track would lead the person to prefer it over another one. In addition, it is likely that the degree of familiarity and uncertainty of appreciation of a musical track change throughout the process of music discovery, although to the best of our knowledge there are no existing studies to support this idea.

We are also interested in assessing mental effort during music discovery as mental effort is an important aspect of the listening experience that might influence how people perceive and respond to music. For example, if a listener finds a musical track to be mentally demanding or grabs the listener's attention, they may be more likely to perceive it as complex, or challenging, which can affect their overall enjoyment of the musical track. Assessing mental effort might also provide insight into cognitive processes involved in music listening and how they vary across different styles or genres. Additionally, understanding the mental effort involved in music listening can have practical applications, such as the design of music education materials or in the development of music recommendation systems that take into account a listener’s mental capacity.

Music discovery is discovering new musical styles, genres, artists, and sounds, possibly through recommendations. More specifically, it refers to the process of gradually becoming certain of a positive liking judgment of unfamiliar music.
Familiarization implies binarity between ‘success of music discovery’ and ‘failure of music discovery'. In other words, the success of music discovery implies that the listeners have a high enough level of confidence about their liking judgment. On the contrary, failure of music discovery implies that the person knows that they do not like the music they listened to.

Several human factors influence music discovery. Within the framework of this study, we will be interested in the effects of emotions, relaxation, and mental effort on music discovery.

Our assumptions will be based on the mental effort and emotions present during relaxation. These are human factors, which are at the heart of our study. Mental effort is defined as a set of resources required to process the information allocated during a task. These resources are the amount of attention and the time allocated to mental effort. Also, mental effort and memorization are two processing steps that happen together. On the other hand, relaxation is defined by a state of reduced mental and physical tension and is characterized by the measurement of skin conductance and heart rate as demonstrated by several studies including (De Jong, Mourik, K.R, & Schellekens, 1973).

2.2 Impacts of mental effort

For this tutored project, we used the following definition regarding mental effort. Mental effort can be defined as the attentional resources allocated to a task. We are going to focus on pupillary responses to assess mental effort because pupillary dilations may be the best ‘‘simple” physiological index available of mental effort or cognitive workload (Kahneman, 1973).

The link between mental effort and emotion should be mainly physiological, as the LC-NE (Locus Coeruleus-Norepinephrine) system is known to be implicated in the pupillary response related to attentional effort and emotional arousal.

Findings suggest that processing of emotional stimuli occurs prior to selective attention and that this pre-attentive processing may serve to enhance stimulus detection (Vuilleumier, Armony, & Dolan, 2003).

The link between mental and relaxation is also pretty physiological, since heart rate/cardiac activity can also be used to assess mental effort, as well as someone’s state of relaxation (Galy, Cariou, & Mélan, 2012)

2.3 Impacts of emotions and relaxation

In this study, we decided to base ourselves on Russel's Circumplex Model, created in 1980. We used this model because it describes many emotions based on two dimensions, valence, and arousal. This model will help us to get a subjective view of the emotions felt by the participants. Moreover, this model is rather simple to understand for the participants and as emotions are classified on this two-dimension basis, it is easy for them to point out the emotions they are feeling during the experiment.
As mentioned above, the emotions in the Russel's Circumplex Model are classified according to two dimensions: valence and arousal. The horizontal valence dimension is a spectrum going from 'unpleasant' emotions to 'pleasant' emotions. The vertical arousal dimension is a spectrum going from 'activation' being a state of high arousal to 'deactivation' being a state of low arousal. This Circumplex Model is composed of four quadrants that each contain several emotions clustered based on their valence and arousal characteristics.

The top right quadrant contains emotions such as 'alert', 'excited', 'elated', and 'happy' which are considered as pleasant and high arousal emotions.
The bottom right quadrant contains emotions such as 'contented', 'serene', 'relaxed', 'calm' which are considered as pleasant and low arousal emotions.
The bottom left quadrant contains emotions such as 'fatigued', 'lethargic', 'depressed', 'sad' which are considered as unpleasant and low arousal emotions.
The top left quadrant contains emotions such as 'upset', 'stressed', 'nervous', 'tense' which are considered as unpleasant and high arousal emotions.

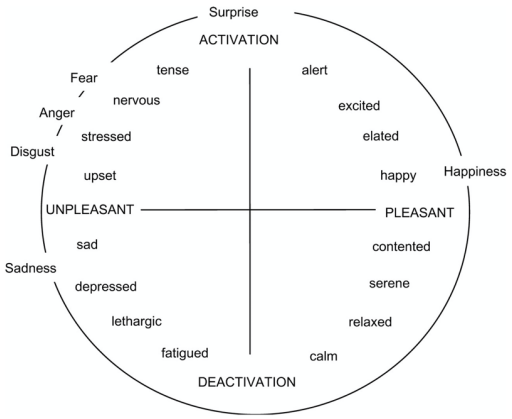


Figure 1 : Russel"s Circumplex Model of emotions

It is possible to induce emotions in at least two ways both visually and auditorily (Gil, 2009). This is the case of our study, the induction of emotions through music. Familiarity can also influence the different emotions felt by the listener. It appears to be a crucial factor in making listeners emotionally engaged with music, as revealed by IRMf data as well as reward circuit activation (Pereira, et al., 2011). Emotions are defined as a certain state that the participant feels or perceives. It can be negative or positive but also of strong or weak activation. They can have a certain impact on music discovery.
As mentioned in Section 2.1, study has shown an impact of emotions on the success of music discovery. However, these emotions may have some impact on this success or failure because the disposition of the person to listen or analyze a musical track will not be the same depending on his emotions. This point is also explained by Andjelkovic in the article Moodplay.

A study undertaken by (De Jong, Mourik, K.R, & Schellekens, 1973) suggests that emotions and relaxation are linked. Indeed, even though each subject has different relaxation needs, they found that listening to preferred music is efficient in enhancing relaxation. The authors of this article distinguish between relaxation as an emotion and relaxation as a physiological state that can happen on its own without regard to emotion. The relaxation state is defined as an absence of anger, tension and the presence of a pleasant effect. They argue that both relaxing music and music that isn't particularly relaxing (but doesn't elicit an emotional reaction) can be used to produce relaxation. According to the authors, the emotion of relaxation is specifically distinguished by a decrease in physiological arousal and a sense of serenity. While subjective feelings of tranquility are not always present, relaxation as a physiological condition can be brought about by things like decreased stimulation, lower arousal, or a sense of security.

Moreover, (Habibi & Damasio, 2014) demonstrated that music changes our behaviors by causing emotions and physiological changes. It means the relaxation state can vary due to the emotions felt. This study also confirms the impact of relaxation on physiological data.
According to (Chabin, et al., 2020) musical tracks can activate the brain's reward system and therefore, elicit strong emotions.
In their study, (Garcia & Van der Brink, 2020) stated that emotions induce variations in physiological factors such as heart rate and skin conductance. This statement explicitly links music and its effects on relaxation. Indeed, if emotions lead to variations in physiological factors, and if music causes emotions, then relaxation and music are linked. However**,** (Ellis & Brighouse, 1952) revealed that there is not only one reactivity trait to music and that it is therefore impossible to conclude that a particular musical track might elicit the same physiological responses for every individual. A musical track that could be considered as "relaxing" could decrease someone's heart rate and increase someone else's heart rate.

There is no existing study to prove the impact of relaxation on the success of music discovery. Therefore, it is a link we will try to establish in our study.

2.4 The role of familiarity

Familiarity allows us to define music discovery by stating that music discovery consists in discovering and appreciating musical tracks we are not familiar with. We studied familiarity as a side question to our research questions to check the theoretical aspects and have solid foundations for our data analysis. To be able to study the familiarity, we had to design a 2-sessions experiment and address familiarity related questions in the post-questionnaire.

Regarding familiarity, there is ample evidence that consumers are driven by familiar and unfamiliar items to make their decisions. Usually, people tend to have a greater affinity for musical tracks they are familiar with (Ward, Goodman, & Irwin, 2014).
Moreover, it has been shown that listening to unfamiliar musical tracks requires greater attentional resources than listening to familiar musical tracks (Heng, 2021) **.** There would therefore be a link between the success of music discovery and mental effort. If no attention is paid, there will likely be a failure of music discovery.

3. Research questions

As mentioned in 1.2 Objectives of the tutored project), our main goal is to investigate how each human factor such as mental effort, emotions or relaxation, influence music discovery.
To reach our main goal, we formulated several research questions.

As we are especially interested in the influence of mental effort on music discovery, we formulated the following two research questions.

- Are we more likely to know if we like a musical track or not when we allocate more mental effort to music discovery?
- Do we know quicker if we like a musical track or not when we allocate more mental effort to music discovery?

Our main objective to check the influence of mental effort on music discovery led us to elaborate on the two specific questions above. We wanted to check if participants knew easier whether they liked a musical track or not when they allocated more mental effort to the task. However, knowing ‘easier’ does not necessarily mean ‘quicker’. We also wanted to check if allocating more mental effort to music discovery could lead the participants to know quicker whether they liked a musical track or not.

Our next aspect of interest is the influence of relaxation on music discovery. We therefore formulated the following questions.

- Do we know quicker if we like a musical track or not when we are relaxed?
- Is the process of music discovery also influenced by emotions that are close to “Relaxation” in Russel”s Circumplex Model?

Our main objective to check the influence of relaxation on music discovery led us to elaborate on the two specific questions above. We wanted to check if participants presented an accelerated decision-making process duration when they felt relaxed. However, we decided not to stop to ‘relaxed’ emotions and see if the emotions that were close enough to relaxation could also influence music discovery.

4. Experimental Protocol

4.1 Track selection

To carry out our protocol, we created playlists composed of different musical tracks that were tailored to each participant. At first, we started with the creation of genre-based playlists, but after several exchanges, we used Spotify's recommendation algorithm as well as Spotify’s popularity index of each musical track. Music with a high listening score is likely to be better known to participants. We therefore favored musical tracks with a low score to minimize the likelihood that they already knew the musical track.
In order to create the playlists from which to select the musical tracks, we asked the participants to provide us with at least 5 liked musical tracks through a Pre-questionnaire.
We then provided these musical tracks as input for the recommendation algorithm, which replied with a set of similar musical tracks. We then selected by hand between ten and fifteen of these recommended musical tracks that seemed suitable for the experiment.

4.2 Equipment

The set of equipment we used is composed of a smartwatch equipped with several sensors allowing us to gather physiological data such as heart rate and skin conductance, bluetooth earphones for participants to listen to the musical track, and Tobii Nano eye-trackers associated with the Tobii Pro Lab software.
To answer our research questions, we asked the participants to undertake an experiment during which we gathered data to assess the studied human factors through two measures. The first measure was subjective answers to a post questionnaire.

This post questionnaire allowed us to assess the emotions felt by the participants while listening to the musical track, their liking judgment, and their mental effort. Moreover, this post questionnaire gave us some information about the familiarity of the participants with each musical track. The second measure we used was objective data from different sensors such as eye-trackers and smartwatches. These allowed us to collect objective indicators of the human factors in which we are interested.

4.3 Experimental protocol

We now present the experimental protocol we proposed to answer the research questions.

4.3.1 Observation context

This study aims at exploring the factors that influence an individual's music discovery and seeks at answering the problems and hypotheses previously seen.
The experiments took place at LORIA, where we used the available equipment to gather physiological data and questionnaires to collect psychological data.
Prior to the experiment, we synchronized data recordings of the smartwatches and eye-trackers by playing a metronome beat on the computer.

4.3.2 Study model and groups

The model of our study is an intra-subject model. There is only one group of participants, who performed several tasks. There are no requirements regarding our participants. However, we have to control several of their characteristics, including their music expertise, age, gender and initial fatigue. Our cohort is composed of five women and four men, aged from 22 to 62 years old. Most of our participants were students, but we also had a retired participant, a teacher researcher, and an executive manager.

4.3.3 Variables

We have two dependent variables that we measure: the success of music discovery, and the time needed by the participants to know why they do or do not like the musical track. We also have two types of independent variables which are mental effort variables (measured through the pupil size and a subjective scale), and the individual relaxation variables (either related to the heart rate and skin conductance and subjective answers to a questionnaire).
During the experiments, we noticed some uncontrollable biases related to personal experience bias and music culture bias. Regarding personal experience, some participants could feel emotions while listening to a musical track that reminded them of a particular trauma or a difficult moment in their life. This could potentially induce bias in the results gathered. Moreover, all participants didn't have the same level of music knowledge. For example, classical music and music classics could mean the same thing for some participants, even

though the first one categorizes a whole musical genre and the second one refers to some musical tracks everyone knows. This could also lead to some bias if the participants didn't make the difference between these two words in the questionnaires.

4.3.4 Protocol

The experiment was organized in two sessions and required beforehand the acquisition of some information about the musical tastes and expertise of the participants. A few days prior to the first session of the experiment, we asked each participant to fill a pre-questionnaire using the LimeSurvey tool, internal to Université de Lorraine, see Appendices: Pre-questionnaire This pre-questionnaire allowed us to gather relevant socio-demographic data (which is anonymized) and to have more information about the participants' musical tastes in order to create a playlist adapted to each subject thanks to the Spotify application, as explained in the part Track selection. More specifically, in the pre-questionnaire, each subject is asked to provide us with at least five appreciated musical tracks. As mentioned above, the protocol was divided into two sessions to better assess the evolution of familiarity and its impacts.

During both sessions, we measured the physiological response of the participants while they listened to these musical tracks. Between the two sessions, we asked them to listen to the musical tracks in their playlist as much as they wanted to.

Regarding the two sessions, the first one aimed at asking the participants to rate the musical tracks in terms of liking and familiarity. During the second session, we asked them once again for their new liking of each musical track as well as their familiarity thanks to the number of times they listened to the musical tracks between the two sessions. During both sessions, we also measured their physiological and behavioral responses when listening to these musical tracks. At the end of the first session, we informed the participants that they could listen to these new musical tracks as much as they wanted between the two sessions. We carried out the study on one participant at a time.

On the experiment day, the participant was invited to enter the room. We first introduced ourselves, briefly presented the context and the objectives of the study and reminded them of their rights as indicated in the consent form. We gave them the consent form and their LimeSurvey ID. We also insisted on the importance of keeping it so that we are able to know which data belongs to them in case they would request their data to be deleted. Then, we completed with the participant the INSEE PCS2003 socio-demographic categorization. We gathered this particular data at this moment rather than in the pre-questionnaire to be able to assist the participant as it might present difficulties for some people. Then, we asked the participant to sit down in front of a computer and we provided the following instruction orally: 'You are going to take part in an experiment in which you are going to hear several musical tracks. We ask you to remain seated in front of the computer, to move as little as possible and not to look away from the screen'.

After formulating the instructions orally, we put the smartwatch in place, proceeded to test the headphones and calibrated the eye-tracker. As the headphones have noise reduction, we had to make sure that the noise reduction parameter was disabled while talking to the subject and activate it when the experiment begins.

While testing the headphones, we had to make the participants listen to a musical track from their playlist to check that it is the right playlist as well as to adjust the sound. To do so, we selected one of the musical tracks that the participants put in the pre-questionnaire. This way, we didn't use any of the musical tracks used during the experiment to test the sound of the headphones.

For the calibration phase, we interacted with the subject by saying: ‘We are now going to move on to the calibration phase. You must place the two points at the bottom of the quadrant. After this, a circle will appear on the screen, you will have to follow it with your gaze without moving your head. Please do not look away from the screen. We leave you with the instructions displayed on the computer screen. However, if you have any questions, we will be in the room to help you’.

Once the calibration phase of the eye-tracker was done, the instructions were displayed on the computer screen.

For each musical track we noted the time at which the listening began as well as the end of the listening which allowed us to synchronize the data during the data analysis. The participants were asked to push the smartwatch button (to register the event) as soon as they know why they do or do not like the music. If the participants already were familiar with the musical track, they were asked to move on to the next one. For each musical track, even if they already were familiar with it or if they could justify why they liked or didn’t like it, the participants had to listen to at least 30 seconds of the musical track before moving on to the next one. The experimenter then kept playing the playlist.
During each task, we displayed Russel’s circumplex of emotions on the screen. The participants had to look at the emotions they were feeling at any moment, which provided us with a dynamic evolution of the emotions throughout the listening process of each musical track.

- The first task consisted of a control task, rather neutral so as not to modify the physiological data of the participants. To do so, the participants heard a metronome calibrated at 60 BPM. This task was designed as a control task to be able to collect baseline data. In addition, during this time, they were able to get familiar with the Russell’s circumplex.
- In the following tasks, the participants had to listen to the next musical track, while watching Russel’s circumplex model of emotions and look at the emotions they related to the most at any moment of the process.

After each of these tasks, a paper post questionnaire was given to the participants, allowing us to collect their emotions, their relaxation and their perceived mental effort (thanks to the RSME scale). The Post questionnaire is available in the appendice section Post-questionnaire

4.3.5 Validation of the experimental protocol

Regarding the validation of our protocol, our study is intended to be used during a conference in mid-July 2023. We therefore had to have our protocol validated by the DPO (data protection officer) to certify that our study did not infringe on the data of the participants as well as their ethics. Moreover, the methods used to collect the data were fully compliant with the national and European legislations and followed the ethical guidelines of the Université de Lorraine.

5. Analysis of the collected data

QR1 : Are we more likely to know if we like a musical track or not when we allocate more mental effort to music discovery?

QR2 : Do we know quicker if we like a musical track or not when we allocate more mental effort to music discovery?

Link between mental effort and music discovery.

In order to investigate this link, we gathered every RSME ratings given by participants for each of the listened musical tracks and associated it with time taken by participants to decide whether or not they liked the musical track.
Two hypotheses were made :

- H0: Increased amount of mental effort does not influence music discovery.
- H1: We are most likely to know quicker whether or not we like a musical track if we exert more mental effort to the process of music discovery.

We then examined two variables: RSME ratings (on a scale from 0 to 150) and Decision Time (in seconds). Decision time values were taken from tags made by participants each time they made their decision on a musical track. Smartwatch's software gave us the tags in Unix timestamps format, and we converted them in seconds. We performed a linear regression on these variables using Jamovi software:

Régression linéaire

Mesures de l'ajustement du modèle

Modèle	R	R^2
1	0.375	0.140

Coefficients du modèle - Decision Time

Prédicteur	Estimation	Erreur standard	t	p
Ordonnée à l'origine	42.747	6.686	6.39	< .001
RSME	0.695	0.169	4.12	< .001

Our model shows a R^2 of 0.14,
Those results showed a weak and positive correlation between the variables and a significant result of the effect of mental effort on musical discovery.

Therefore, we can reject our null hypothesis and highlight the fact that we are most likely to know quicker whether or not we like a musical track if we exert more mental effort to the process of music discovery, even if the effect won't be extremely large.

As RSME ratings were subjective measures we wanted to confront it with objective measures like pupil diameter using pupillometry. We intended to cut the dataset exported from the eye tracker and to calculate an average pupil diameter measure for each trial and for each participant to compare it with associated RSME ratings and decision time, but we didn't have time to do it since treating these data was a long process. What we tried in order to cut the dataset properly was to use recording timestamps. Recording timestamps were taken every 16 or 17 milliseconds, so any difference between two recordings that would be larger than these two values would have highlighted a change of trial. Even doing so, pupillometric measures couldn't be correctly associated with RSME ratings and decision time, because we didn't have the same amount of average pupillometric measures as RSME and decision time measures. The entire process is detailed on a jupyter notebook available in the project deliverables.

These results aren't enough to conclude on our RQ1 since there are definitely other variables than RSME ratings that should explain decision time variations. To explore that, we should've added an analysis by linking RSME ratings with other measures like emotions measured by eye-tracker and relaxation state.

QR3 : Do we know quicker if we like a musical track or not when we are relaxed?

Regarding our third research question "Do we know quicker if we like a musical track or not when we are relaxed?", we collected the time needed for each participant to push the smartwatch button during both sessions (As a reminder, the participants had to push the button when they were able to justify why they liked or didn't like the musical track).
We also gathered the physiological data collected by the watch (such as heart rate (HR) and electrodermal activity (EDA)). Some of the data we used are grouped in the Appendices**.**

Heart rate baselines

The first thing we did was to calculate the heart rate baseline of each participant and compared the differences between the baseline and the participant's heart rates during session 1 and during session 2. We have the following hypotheses:

- H0: The heart rate difference between baseline and session 1 is equal to the difference between baseline and session 2.
- H1: The heart rate difference between baseline and session 1 isn't equal to the difference between baseline and session 2.

The results show that the mean difference of heart rate between baseline and session 1 is -3.725 whereas it is -0.4125 between baseline and session 2. We then checked the distribution's normality by realizing a Shapiro-Wilk test to be able to do a Student test afterwards on the data.

Test t pour échantillons appariés

Test t pour échantillons appariés

			statistique	ddl	p
Difference Baseline - Session1	Difference Baseline - Session2	t de Student	−1.52	7.00	0.172

Note. H_a $\mu_{\text{Mesure 1 - Mesure 2}} \neq 0$

Test de normalité (Shapiro-Wilk)

			W	p
Difference Baseline - Session1	-	Difference Baseline - Session2	0.937	0.583

Note. Une valeur p faible suggère une violation de la condition de normalité

Thanks to the Student test, we observe that p-value is equal to 0.172, which doesn't allow us to reject the null hypothesis. We can conclude that the heart rate difference between baseline and session 1 is not substantially different to the difference between baseline and session 2. (We can interpret these results by stating that the participants were not on average more relaxed during session 2 compared to session 1).

Decision time to push the smartwatch buttons.

Next, we got interested in the time it took all participants to push the smartwatch button during both sessions. To do so, we calculated the average time it took the participants to push the button. We have the following hypotheses:

- H0: The average time needed by the participants to push the button during session 1 is equal to the time needed during session 2.
- H1: The average time needed by the participants to push the button during session 1 is not equal to the time needed during session 2

On average, the participants needed 73.39 seconds to push the button during session 1 and 57.33 seconds during session 2. We performed a Shapiro-Wilk test to check the normality of the distribution, and then we carried out a Student test.

Test t pour échantillons appariés

Test t pour échantillons appariés

			statistique	ddl	p
Decision-time Session 1	Decision-time Session 2	t de Student	1.12	7.00	0.298

Note. H_a $\mu_{\text{Mesure 1 - Mesure 2}} \neq 0$

Test de normalité (Shapiro-Wilk)

			W	p
Decision-time Session 1	-	Decision-time Session 2	0.926	0.480

Note. Une valeur p faible suggère une violation de la condition de normalité

We observed that the p-value is equal to 0.298, which doesn't allow us to reject the null hypothesis. We can conclude that the average time needed by the participants to push the button during session 1 is equal to the time needed during session 2. From this conclusion, we can state that participants took the same amount of time to know why they did or didn't like the musical track, so the same time to push the button in both sessions.

In the next part of this report, we studied familiarity as a side question, as mentioned in section 2.4

The feeling of familiarity

Our study consisted in a 2-session experiment so that we were able to get interested in the feeling of familiarity for each musical track. Regarding familiarity, we gathered the data from the post-questionnaires that the participants filled in after pushing the smartwatch button. The familiarity was assessed thanks to a Likert Scale (see Post-Questionnaire in the Appendices) as were the relaxation and the appreciation of the musical track. However, when asked about their relaxation level and appreciation level, none of the participants answered with the scale item "I completely disagree" whereas some of them answered with this particular item for the familiarity question. This caused troubles when transforming the text answers into integers answers. Indeed, if "Completely disagree" was equal to 0 and "Strongly disagree" was equal to 1 for the Familiarity criterion, it would lead to a shift with the following items: "Disagree" would be equal to 2 for the familiarity criterion instead of 1 for the relaxation/appreciation criteria etc. We decided to attribute 0 to both items "Completely disagree" and "Strongly disagree" to harmonize and smooth the data. The table showing the transformation of the data is presented in the Appendices.

Thanks to this transformation, we then were able to calculate the average feeling of familiarity of the participants for each session. There are 7 out of our 8 participants who felt more familiar with the musical tracks during session 2. This participant's results from outliers' data.

Regarding familiarity, we have the following hypotheses:

- H0 : The average feeling of familiarity is equal in session 1 compared to session 2
- H1 : The average feeling of familiarity isn't equal in session 1 compared to session 2

Test t pour échantillons appariés

Test t pour échantillons appariés

			statistique	ddl	p
Familiarity session 1	Familiarity session 2	t de Student	–3.88	7.00	0.006

Note. H_a $\mu_{\text{Mesure 1 - Mesure 2}} \neq 0$

Test de normalité (Shapiro-Wilk)

			W	p
Familiarity session 1	-	Familiarity session 2	0.880	0.189

Note. Une valeur p faible suggère une violation de la condition de normalité

On average, the participants felt less familiar with the musical tracks in session 1 (1.00) compared to session 2 (3.17). We performed a Shapiro-Wilk test to check the normality of the distribution, and then we carried out a Student test.
We observed that the p-value is inferior to 0.05, which doesn't allow us to accept the null hypothesis. We have to reject it and conclude that the average feeling of familiarity isn't equal in session 1 compared to session 2. From the results obtained, we can state that the feeling of familiarity of the participants is higher in session 2 compared to session 1, which makes sense as they never heard the musical tracks in session 1 and got to be more familiar with them between the two sessions.

Link between relaxation and familiarity

We now get interested in the link between the feelings of relaxation and familiarity. We know that the participants felt more relaxed during session 2 and that they should have been more familiar with the musical tracks during session 2 than during session 1.
We have the following hypotheses :

- H0: We are not more relaxed when we listen to a musical track we are familiar with
- H1: We are more relaxed when we listen to a musical track we are familiar with

We performed a Correlation Matrix between relaxation and familiarity for both sessions.

Matrice de corrélation

Matrice de corrélation

		"Relaxed" Session 1	"Relaxed" Session 2	Familiarity session 1	Familiarity session 2
"Relaxed" Session 1	Rho de Spearman	—			
	valeur p	—			
"Relaxed" Session 2	Rho de Spearman	0.813 *	—		
	valeur p	0.014	—		
Familiarity session 1	Rho de Spearman	–0.110	–0.082	—	
	valeur p	0.796	0.846	—	
Familiarity session 2	Rho de Spearman	0.419	0.611	0.300	—
	valeur p	0.301	0.108	0.470	—

Note. * p < .05, ** p < .01, *** p < .001

We observed that the p-value of the correlation between familiarity and relaxation in session 1 is 0.796 and the p-value of the correlation between familiarity and relaxation in session 2 is 0.108. From these results, we can state that there are no strong correlations between familiarity and relaxation in either of the sessions.

The correlation matrix below also gives a clear glimpse of the correlation between the different variables of our study.

Matrice de corrélation

Matrice de corrélation

		Decision-time Session 1	Decision-time Session 2	Average HR session 1	Average HR session 2	"Like" Session 1	"Like" Session 2	"Relaxed" Session 1	"Relaxed" Session 2	Familiarity session 1	Familiarity session 2
Decision-time Session 1	Rho de Spearman	—									
	valeur p	—									
Decision-time Session 2	Rho de Spearman	0.167	—								
	valeur p	0.703	—								
Average HR session 1	Rho de Spearman	-0.333	0.286	—							
	valeur p	0.428	0.501	—							
Average HR session 2	Rho de Spearman	-0.524	-0.286	0.762 *	—						
	valeur p	0.197	0.501	0.037	—						
"Like" Session 1	Rho de Spearman	0.450	0.288	0.084	-0.270	—					
	valeur p	0.310	0.531	0.844	0.558	—					
"Like" Session 2	Rho de Spearman	-0.108	-0.036	0.000	0.072	0.572	—				
	valeur p	0.818	0.939	1.000	0.878	0.138	—				
"Relaxed" Session 1	Rho de Spearman	0.360	0.090	-0.299	-0.162	0.669	0.512	—			
	valeur p	0.427	0.848	0.471	0.728	0.070	0.195	—			
"Relaxed" Session 2	Rho de Spearman	0.198	-0.036	-0.299	-0.180	0.765 *	0.813 *	0.813 *	—		
	valeur p	0.670	0.939	0.471	0.699	0.027	0.014	0.014	—		
Familiarity session 1	Rho de Spearman	-0.118	0.394	-0.491	-0.611	-0.027	-0.178	-0.110	-0.082	—	
	valeur p	0.801	0.382	0.217	0.145	0.949	0.673	0.796	0.846	—	
Familiarity session 2	Rho de Spearman	0.071	0.643	-0.048	-0.143	0.575	0.491	0.419	0.611	0.300	—
	valeur p	0.906	0.139	0.935	0.783	0.136	0.217	0.301	0.108	0.470	—

Note. * p < .05, ** p < .01, *** p < .001

Regarding the objective data gathered by the watch, we have a p-value of 0.501 for the correlation between the time needed to push the button during session 2 and the average heart rate during session 2.

Regarding the subjective data gathered thanks to the post-questionnaires, we have a p-value of 0.939 for the correlation between the time needed to push the button during session 2 and the feeling of relaxation felt by the participants while listening to the musical track.
We have a p-value of 0.108 for the correlation between the feeling of familiarity in session 2 and the feeling of relaxation in session 2.

Another interesting result is the correlation between the liking judgment in session 2 and the feeling of relaxation in session 2 which is a significant correlation (ρ = 0.813)

QR4 : Is the process of music discovery also influenced by emotions that are close to “Relaxation” in Russel’s Circumplex Model?

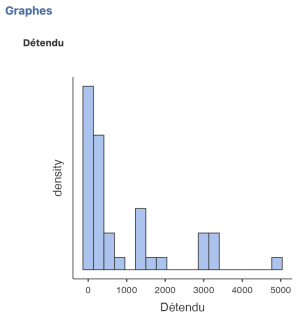
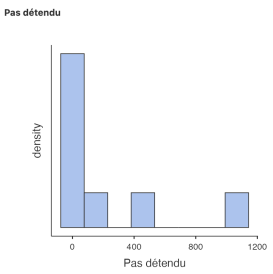
We seek to understand the impact of “relaxing” type emotions on the process of music discovery. As a reminder, the process of music discovery is defined by the certainty of a judgment on the appreciation of unknown musical tracks. To do this, we will first check that the people who say they feel relaxed in the post-questionnaire also looked at these emotions during the listening phase. Then we will associate the appreciation of the musical track (the fact of having liked or not a track) with the state of relaxation. Finally on the study of the link between the decision time (time dedicated to the positive or negative appreciation of the track) associated with the emotions of relaxed types. Only 7 of the 9 participants were considered in this research question because we encountered an issue when synchronizing the data.

Link between the emotions felt during listening with the appreciation of relaxation in the post-questionnaire.

To carry out this study, we used the data available in the appendices, Data section**.**
We separated the data into 2 groups based on the response in the post-questionnaire, people feeling relaxed and people not feeling relaxed. We want to know if the means of the two groups are equal or not. It remains important to take into account the fact that our samples in the 2 groups are not the same size. Here we have 2 type-matched samples.
We make the assumptions:

- H0: There is no difference between the groups in how relaxed they felt while listening.
- H1: There is a difference between the groups in how relaxed they felt while listening.

Here is a representation of our data using two histograms:

Diagram 1 : Histogram representing of the sum of relaxing type emotions according to the relaxed aspect of individuals	*Diagram 2 : Histogram representing of the sum of relaxing-type emotions according to non-relaxed individuals*
	

We performed a normality test to verify that our two groups respect a normal law (ρ=0.357).

To then be able to compare the means, we carried out a Student's test on paired samples.

We find that our p-value is less than 0.05 (ρ=0.049). So we can accept H1 and reject H0.

Test t pour échantillons appariés

Test t pour échantillons appariés

			statistique	ddl	p
Détendu	Pas détendu	t de Student	2.38	7.00	0.049

Note. H_a $\mu_{\text{Mesure 1 - Mesure 2}} \neq 0$

Test de normalité (Shapiro-Wilk)

			W	p
Détendu	-	Pas détendu	0.910	0.357

Note. Une valeur p faible suggère une violation de la condition de normalité

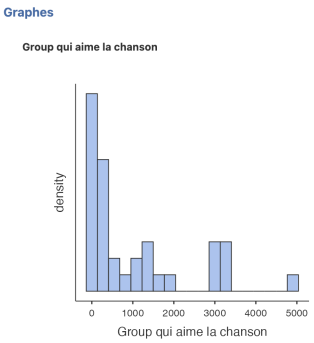
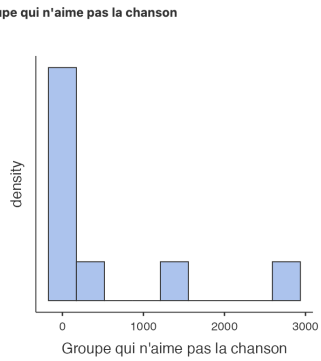
We can therefore conclude that there is a significant difference between the 2 groups, people who were relaxed while listening observed these same emotions on Russel's Circumplex model. The emotions observed during the listening phase can therefore be associated with a feeling of relaxation, which is indicated in the post-questionnaire.

Link between the emotions felt during listening with the final appreciation of the musical track.

To carry out this study, we used the data available in the Appendices ,Data section
We separated the data into 2 groups using the post-questionnaire data, people who liked the musical track and people who did not like the musical tracks listened to. We want to know if there is a link between the emotions felt during listening (here relaxing emotions) and the appreciation of it. To do this, we will make two hypotheses:

- H0: There is no difference in feelings of relaxing type emotions (calm, serene and relaxed) between people with a good appreciation of music and those with a poor appreciation.
- H1: There is a difference in the feeling of relaxing type emotions (calm, serene and relaxed) between people with a good appreciation of music and those with a poor appreciation.

Here is a representation of our data using two histograms:

Diagram 3: Histogram representing the sum of relaxing emotions according to the positive appreciation of the musical track	*Diagram 4 : Histogram representing the sum of relaxing emotions according to the negative appreciation of the musical track*
	

We carried out a test of normality on the paired samples, the p-value being equal to 0.914, our samples follow a normal law. To then be able to compare the means, we carried out a Student's test on paired samples.

We find that our p-value is greater than 0.05 (ρ=0.162). We can therefore reject H1 and accept H0.

Test t pour échantillons appariés

Test t pour échantillons appariés

			statistique	ddl	p
Group qui aime la chanson	Groupe qui n'aime pas la chanson	t de Student	1.54	8.00	0.162

Note. H_a $\mu_{\text{Mesure 1 - Mesure 2}} \neq 0$

Test de normalité (Shapiro-Wilk)

			W	p
Group qui aime la chanson	-	Groupe qui n'aime pas la chanson	0.972	0.914

Note. Une valeur p faible suggère une violation de la condition de normalité

We can conclude that there is not a significant difference between the 2 groups. The people who liked the musical track did not have a significantly greater sum of relaxing emotions than the group who did not like the musical track.

Link between decision time and relaxing type emotions felt during listening

To carry out this study, we used the data available in the appendices, Data section
We seek to highlight the correlation between the emotions of relaxing types with the decision time of the participants.

We therefore make two hypotheses:

- H0: Emotions of relaxing types do not positively influence the process of music discovery.
- H1: Emotions of relaxing types positively influence the process of music discovery.

In order to be able to answer our research question, we had to make sure that the “relaxing” type emotions were correlated with each other. So we want to combine calm, serene and relaxed emotions together. We take the value of ρ at 0.05.

Matrice de corrélation

Matrice de corrélation

		Moyenne AOI relaxé	Moyenne AOI serein	Moyenne AOI calme
Moyenne AOI relaxé	r de Pearson	—		
	valeur p	—		
Moyenne AOI serein	r de Pearson	0.945	—	
	valeur p	0.001	—	
Moyenne AOI calme	r de Pearson	0.753	0.760	—
	valeur p	0.051	0.047	—

We find that emotions are well correlated with each other. We can therefore say that the “relaxing” types of emotions are: relaxed, serene and calm.

Then we carried out two tests in order to validate or invalidate our hypotheses: the first corresponds to a linear regression associating the average of the decision times of the participants with the average of the sums of the different AOIs (area of interest of the participants).
When the participants looked at the relaxed emotion, which meant that they were relaxed, the eye tracking took note of this emotion. So we summed these different emotions.
We obtained:

- A linear regression which highlights the link between decision time and relaxed emotion

Régression linéaire

Mesures de l'ajustement du modèle

Modèle	R	R^2
1	0.414	0.171

>

Coefficients du modèle - Moyenne temps passé avant de savoir si une musique plait ou non

Prédicteur	Estimation	Erreur standard	t	p
Ordonnée à l'origine	78.0229	17.5919	4.44	0.007
Moyenne AOI relaxé	0.0330	0.0325	1.02	0.356

- A linear regression which highlights the link between decision time and serene emotion

Régression linéaire

Mesures de l'ajustement du modèle

Modèle	R	R^2
1	0.480	0.230

Coefficients du modèle - Moyenne temps passé avant de savoir si une musique plait ou non

Prédicteur	Estimation	Erreur standard	t	p
Ordonnée à l'origine	75.3171	17.3213	4.35	0.007
Moyenne AOI serein	0.0415	0.0340	1.22	0.276

- A linear regression that highlights the link between decision time and calm emotion

Régression linéaire

Mesures de l'ajustement du modèle

Modèle	R	R^2
1	0.0246	6.04e–4

Coefficients du modèle - Moyenne temps passé avant de savoir si une musique plait ou non

Prédicteur	Estimation	Erreur standard	t	p
Ordonnée à l'origine	90.49428	19.4048	4.6635	0.006
Moyenne AOI calme	0.00496	0.0903	0.0550	0.958

We note that thanks to these three linear regressions no correlation between each emotion and the decision time is possible because all the p-values are higher than our error threshold set at 0.05 (ρ=0.958, ρ=0.276, ρ=0.356).

We then associated the 3 emotions with each other, because as mentioned above, these emotions had a strong correlation.

By associating the 3 sums of emotions we obtained this linear regression:

Régression linéaire

Mesures de l'ajustement du modèle

Modèle	R	R^2
1	0.360	0.130

Coefficients du modèle - moyenne temps

Prédicteur	Estimation	Erreur standard	t	p
Ordonnée à l'origine	77.68575	19.86982	3.910	0.011
somme total AOI	0.00223	0.00259	0.863	0.428

By associating the average decision time for each participant with the average “relaxed” type emotions (including relaxed, calm and serene) of each participant, we found that there is no correlation between the decision time and the relaxation state of the participant in terms of emotions, because the p-value is greater than 0.05 (ρ=0.428).

Our hypothesis H1 is therefore rejected and H0 is accepted, so we cannot conclude on the influence of the emotions of relaxed types on the decision time of the participants as well as on the process of music discovery.

6. Interpretation

6.1 Global analysis of results

In this project, we collected data on different parameters (mental effort, relaxation, emotion, familiarity) and different scales of parameters (objective or subjective) to investigate their link with the process of music discovery.
Our results shows :

- A significant effect of mental effort on music discovery. (1)
- A strong correlation between objective and subjective measures of emotions. (2)
- No correlation between the relaxed-type emotions felt during music discovery and the final appreciation of it. (3)
- A correlation between the relaxed-type emotions “Serene” and “relaxed” but no correlation with the relaxed-type emotion “calm”. (4)
- No significant effect of each relaxed-type emotions on music discovery. (5)
- No significant difference between participants’ objective relaxation state between the two sessions. (6)
- No significant difference in the participants’ decision time over both sessions. (7)
- The average measure of familiarity by participants is significantly different between session 1 and session 2 (this measure is smaller in average in session 1) (8)
- No strong correlation between familiarity and relaxation in both sessions (9)
- A significant difference between means of feeling of familiarity and feeling of relaxation (10)
- No correlation between objective and subjective measures of relaxation (11)
- A strong correlation between feeling of relaxation and music appreciation. (12)

(1) Shows that music discovery might be a low-mental effort process and is fitting to our expectations. However, these results have to be considered cautiously: it should have been better to make sure of this by searching for any correlation between subjective (RSME ratings) and objective (pupillometry) measures.
(2) Indicates that participant’s self-reported emotional experiences align with the objective measurements and shows how consistent and reliable these self-reports are.
(3) Makes some sense since a participant doesn’t really need to be or feel relaxed to like a musical track. An example: If the participant likes the musical track because it finds it exciting and then feels excited.
(4) This indicates that a person doesn’t necessarily feel calm if he/she feels relaxed or serene. That is a counterintuitive result since we expected them to be close to each other. Further analysis might be needed.

(5) This also doesn't fit our expectations since we expected an effect of relaxation on music discovery. Treatment of data might be incomplete, or Area of Interest might not have been traced correctly enough. Further analysis is needed on that matter.
(6) This shows that participants didn't seem objectively more relaxed in session 1 than in session 2.
(7) This shows that there is no significant effect of familiarity on music discovery even though (8) shows a difference of familiarity between session 1 and session 2. (7) shows that whether a participant feels familiar or unfamiliar with a musical track doesn't affect the decision-making process duration. This doesn't fit our expectations. We expected that familiarity might accelerate the decision-making process.
(8) This shows that participants are less familiar with musical tracks during session 1 than session 2, which totally fits our expectations oppositely to (7).
(9) This shows that we are not necessarily more relaxed when we listen to musical tracks, we are familiar with. This doesn't fit our expectations. We expected that participants would feel more relaxed when listening to familiar musical tracks.
(10) Shows that apparently, we are not necessarily more relaxed when we listen to musical tracks, we are familiar with. This fits with (6) but does not fit our expectations.
(11) Our correlation matrix shows no link between subjective measures and objective measures of relaxation. The lack of consistency shown in the correlation matrix between subjective measures and objective measures of relaxation might be explained by the delay to self-report subjective measures, since the participants had to wait the end of the musical track to report how relaxed they felt, the collection of these data wasn't as instant as collection of heart rate or emotions with the eye-tracker for example and they might have confused how they felt when answering to the post-questionnaire versus how they felt during the actual musical track listening. Therefore, we should consider results including subjectives measures of relaxation cautiously.
(12) This shows that we are most likely to be relaxed if we like the music. But as discussed with (11) and subjective measures of relaxation, this result should be considered cautiously.

6.2 Limitations

We would have liked to have more participants for our study to be scientifically valid. The lack of time was an important factor as we waited for the DPO's response, which slowed us down in carrying out the experiments and leaving us little time to finish data analysis. In addition, despite all the precautions we have taken, our study includes many biases that we could not have avoided before carrying out this study.

6.3 Conclusion

With these results we were able to highlight the fact that we know (slightly) quicker if we like a musical track or not by exerting more mental effort into the process of music discovery. We also found no significant relationships between music discovery and emotions felt, as well as relaxation, which wasn't our expectations. However, it would be wrong to think mental effort is the only predictor of music discovery. Further analysis should be considered on the matter.

7. General Conclusion

To conclude, this project was composed of two main parts: the bibliography and the experiment.
Our first tasks during the bibliography writing was to find all the necessary and pertinent resources we could find to properly define every key word of this project and be able to find several research questions. This work allowed us to have a look over the existing studies to extract important information and some models of experimental protocol, which proved to be useful for the remaining part of the tutored project.
The second part of this project was about thinking and designing from scratch an experimental protocol that would allow us to gather physiological and psychological data thanks to the available equipment. The data gathered regarding the mental effort, the emotions and the relaxation allowed us to proceed to a data analysis in order to answer our research questions.

In addition, this project allowed us to have an overview of the researcher's work, from the bibliographic part to the study of the results as well as to its interpretation and its limits. Thus, thanks to this project, we have been able to see our research questions and our work evolve. In addition, we were able to work in groups and better understand the conflicts or points of interest of each.

What has been useful to us

Much knowledge was beneficial in the realization of this work. Some knowledge such as the link between emotions felt, cognition and actions taken that we acquired during our bachelor's and master's degrees was particularly important to better understand the subject. In addition, our group is made up of people who have not all completed the MIASHS license in Nancy, which allowed us to corroborate our knowledge to make this report. The subjects 'Technology of behavior analysis' as well as 'Behavioral analysis' were very useful to us from the development of the protocol to the analysis of the results. Indeed, in these subjects, we learnt how to use tools such as the eye-trackers and how to manipulate the data gathered.

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Appendices

The musical interests questions are questions taken from the Gold-MSI questionnaire

Pre-questionnaire

This pre-questionnaire allows us to know musical tastes of our participants (to be completed a few days before the experiment, during the signature of consent form). We will use this pre-questionnaire to create a specific playlist for each participant.

How old are you? _____

What is your gender?

- Male
- Female

How often do you listen to music?

- Every day
- A few days a week
- Less than two days a week

- A few times a month
- Never

Please circle the most appropriate category :

I engaged in regular, daily practice of a musical instrument (including voice) for **0 / 1 / 2 / 3 / 4-5 / 6-9 / 10 or more** years.

I have had formal training in music theory (solfegio) for **0 / 0.5 / 1 / 2 / 3 / 4-6 / 7 or more** years.

I have had **0 / 0.5 / 1 / 2 / 3-5 / 6-9 / 10 or more** years of formal training on a musical instrument (including voice) during my lifetime.

Name at least 5 musical tracks that you appreciate (give the name of the artist and the name of the musical track):

1- _____

2- _____

3- _____

4- _____

5- _____

6- _____

7- _____

8- _____

9- _____

10- _____

Rank your three favorite musical genre (1 is the one you like the most, 3 is the one you like the least) :

- Classic
- Pop
- Jazz
- Rock
- French variety
- Experimental music (relaxing)

- Metal
- World music
- Soul/Funk
- Folk
- Hip-Hop
- Rap
- Electronic music

Rank the three musical genre you hate (1 is the one you hate the most, 3 is the one you hate the least):

- Classic
- Pop
- Jazz
- Rock
- French variety
- Experimental music (relaxing)
- Metal
- World music
- Soul/Funk
- Folk
- Hip-Hop
- Rap
- Electronic music

I usually know when I am hearing a musical track for the first time:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I am intrigued by musical styles I am not familiar with and want to find out more:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

Musical tracks rarely evoke emotions for me:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I have trouble recognizing a familiar musical track when played in a different way or by a different performer:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I am able to identify what is special about a given musical track:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I am able to talk about the emotions that a musical track evokes for me:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

When I hear a musical track, I can usually identify its genre:

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

Regarding the pre-questionnaire, we used questions from the Gold-MSI to gather data on the musical interest of the participant, on the emotions music might elicit and on their ability to identify elements from a musical track. Moreover, we used Likert-Scale to better assess all of these aspects and better understand the degree of agreement or disagreement of the participant.

Post-questionnaire

Session 1

At the end of each listening, the participants answer questions to know if they could recognize the musical genre, to know whether they liked this music or not, whether they felt relaxed or not during the listening, the emotions felt as well as the mental effort allocated to the task thanks to the RSME Scale.

What musical genre did you hear? (You can select several of them)

- Classic
- Pop
- Jazz
- Rock
- French variety
- Experimental music (relaxing)
- Metal
- World music
- Soul/Funk
- Folk
- Hip-Hop
- Rap
- Electronic music
- I am not sure

I liked this musical track.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I felt relaxed while listening to this musical track.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

In the next part of this questionnaire, we will ask the participant to justify their appreciation of the musical track. There will be no judgment.

Why did you or didn't you like the musical track? What elements made you like it or dislike it? (delete as appropriate)

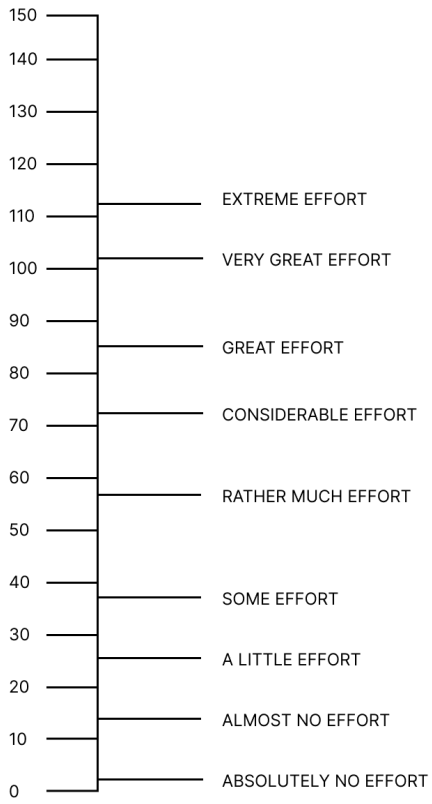
I liked / I didn't like this musical track because _____

_____

_____

The next question targets the mental effort you allocated to music discovery. Was it difficult for you to grasp the musical track, to recognize what you appreciate etc?

Circle the number that represents how difficult it was for you to say why you did or didn't like the listened musical track.



RSME Scale

I am enthusiastic to carry on with the experiment and discover new music.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I am feeling tired.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

I am familiar with the genre I listened to.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

Can you justify? (Optional)

_____

_____

_____

I am familiar with the musical track I listened to.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

Can you justify? (Optional)

_____

_____

_____

I am familiar with the artist I listened to.

Completely disagree	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Completely agree
O	O	O	O	O	O	O

Can you justify? (Optional)

_____

_____

_____

Session 2

The post questionnaire will be the same for the two sessions of the experiment. However, in the post-questionnaire for the second session, there will be the following two questions that might help us to better understand the participant's responses regarding its familiarity with the musical tracks :

Between the first and the second session of this experiment, did you listen to the musical track of your playlist?

- Yes
- No

If you did, how much?

- 1 to 5 times between sessions
- 5 to 10 times
- 11 times or more

Flyer model

We produced a flyer, the purpose of which was to make as many participants as possible want to come and take part in our experience.
The colorimetry as well as the theme will be included in the poster.

Data

In this section, we aggregated some of the data we used to answer our research questions.

Participant's ID	HR baseline	HR during session 1	HR during session 2
1013759404	89.94	88	86.77
298780196	91.97	89.83	81.04
721365663	72.83	81.93	81.38
850988206	96.72	90.86	
903412832	68.7	71.35	75.95
1261293994	54.76	68.39	62.69
1524650246	105.76	93.29	94.52
198367211	76.33	85.19	70.43
2067560969	67.98	79.99	78.69

Participant's ID	Difference baseline-session 1	Difference baseline-session 2
1013759404	1.84	3.07
298780196	2.14	10.93
721365663	-9.1	-8.55
850988206		
903412832	-2.65	-7.25
1261293994	-13.63	-7.93
1524650246	12.47	11.24
198367211	-8.86	5.9
2067560969	-12.01	-10.71

Participant's ID	Average time to push the button during session 1	Average time to push the button during session 2
1013759404	23.33	36.4
298780196	134.2	98.8
721365663	52.33	40
850988206	101.5	
903412832	81.62	31.87
1261293994	72.8	62.2
1524650246	47.29	47.28
198367211	56.6	102.8
2067560969	90.83	39.33

The following table explains the transformation we did to be able to analyze the data:

Likert Scale	Transformation for Relaxation / Appreciation	Transformation for Familiarity
Completely disagree	x	0
Strongly disagree	0	0
Disagree	1	1
Neither agree nor disagree	2	2
Agree	3	3
Strongly agree	4	4
Completely agree	5	5

Participant's ID	Familiarity in session 1	Familiarity in session 2
198367211	1,2	2,6
298780196	0	3,33
721365663	0	3
903412832	0	2,25
1013759404	0	2,83
1261293994	5	3,8
1524650246	0	3,875
2067560969	1,83	3,66

Participant's ID	Average AOI emotion type 'relax'	Average AOI emotion type 'calm'	Average AOI emotion type 'serene'	Sum of emotions relax AOI
298780196	777,66	919,16	252,8	11698
2067560969	209,83	107,66	117,16	2608
850988206	1019,33	764	236,5	12137
721365663	572,5	562	426,83	9368

903412832	35,875	100,625	3,375	1119
1261293994	196	236	79,63	5628
198367211	3,2	5	1,4	48

Group that loves the song	Group that doesn't like the song	Relaxed	Not relaxed
984	2764	1394	33
1394	23	3343	1067
3343	0	146	0
146	429	3067	18
3067	1259	42	16
42	163	1443	84
33	10	90	429
1067	18	249	11
1443	16	3261	
90		4902	
249		3206	
3261		166	
4902		1781	
3206		1259	
166		3099	
1781		3052	
11		160	
3099		154	
3052		143	
84		78	
160		51	
154		163	
143		528	
78		1710	
51		706	
528		1287	
1710		297	

706		398	
1287		521	
297		61	
398		10	
521		110	
61		14	
110		0	
14		1287	
0		297	
0		398	
		521	
		61	
		10	
		110	
		14	
		0	
		0	