Match in emotional content in lyrics and melody enhances likeability

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# **Abstract**

**Keywords:** emotional content, lyric, melody, music, enhanced likeability, BOLD, fMRI

# **Introduction – Assignment #2**

Research question

* Should be stated in bold and after the question this should be put in parentheses **(Research Question Statement: Assignment #1)**

Hypothesis

Literature that motivates research (Putkinen et al., 2021), (Mori, 2022), (Eerola & Vuoskoski, 2013), **(Hunter et al., 2008)**, (Juslin & Västfjäll, 2008), (Juslin & Laukka, 2004), (Zatorre & Salimpoor, 2013), (Blood & Zatorre, 2001), (Zatorre et al., 2002)

Design table (see below)

**NOTES**

* Melodies of major and minor mode will be paired with lyrics with either a more positive or negative sentiment. Earlier experiments showed that music in major mode evokes a positive emotional response while music in minor mode evokes a negative response, based on self-report on a valence scale. A functional MRI will be used to measure the blood oxygen level-dependent signal
* This will be research by participants listening to music while getting a fMRI scan, further the participants will self-report on their emotional response. The functional MRI is used to measure the BOLD signal in the liking network so the signal can be compared when listening to matched and mismatched valence. The self-report is used to control if the songs we expect to be experienced with higher or lower valence is experienced like that.
* fMRI looking at the liking network (Putkinen et al., 2021), based on this paper I will look at whether or not the participants like the music or not (WERE SPECIFICALLY DO WE EXPECT TO SEE ACTIVITY, regions of interest (ROI))

**Key and tempo** = the sound of the melody (happy/sad), (Green et al., 2008), (Overy & Molnar-Szakacs, 2009), (Gagnon & Peretz, 2003)

**Sentiment analysis,** (“Python | Sentiment Analysis Using VADER,” 2019)

**Preference in music** (Kreutz et al., 2008)

**Predictive coding** (Koelsch et al., 2019),

RESEARCH QUESTION/HYPOTHESIS PART DONE + DESIGN TABLE DONE

This study aims to determine **if what makes music likable is the match or mismatch between the sentiment of lyrics and the valence of melodies (Research Question Statement: Assignment #1). This question led to the hypothesis** that the blood oxygen level-dependent (BOLD) signal in the 4 regions of interest is enhanced when the sentiment of the lyrics is matched with melodies of corresponding valence.

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| --- | --- | --- | --- | --- |
| **Question** | **Hypothesis and null hypothesis** | **Sampling plan** | **Analysis plan** | **Interpretation given different outcomes** |
| What makes music likable is the match or mismatch between the sentiment of lyrics and the valence of melodies | **H1:** That the blood oxygen level-dependent (BOLD) signal in the liking network is enhanced when the sentiment of the lyrics is matched with melodies of corresponding valence.  **H0:** the BOLD-signal in the linking network is the same both, when the sentiment of the lyrics and the valence of the melody, match and mismatch. | The data will be collected through a experiment with a within-subject design, where participants will be exposed to various songs while their BOLD signal is measured by fMRI | On the data a linear mixed effect analysis will be conducted using R (R core Team, 2019). The outcome variable will be the BOLD signal, the valence of the melody and sentiment of the lyrics will be entered as fixed effect, while the participant ID is entered as the random effect because I expect each individual to have their own baseline. | If a significant difference is found it would imply the likability of music is dependent on the match between the sentiment of the lyrics and the valence of the melody |

# **Methods – Assignment #3**

All referenced code and data are available see the Code availability and Data availability section.

## Ethics

If the study were to run it would be conducted in accordance with relevant ethical regulations and approval from the Research Ethics committee would be sought. Before the experiment all participants would be presented with a written consent form and informed written consent would need to be given for further participation. The participants would be informed withdrawal of consent is always possible, but after data anonymization it would no longer be possible to remove specific data. The participants would be compensated for their participation.

## Pilot study

33 participants were a part of the study, 66.67% were female, had a mean age of 22.45(sd=5.97) and their ages ranged from 15-52. The experiment was conducted through Google survey, where the participants were presented 8 sound clips. The experiment was a within subject design. The songs used as stimuli were collected from Epidemic Sound (<https://www.epidemicsound.com/music/featured/>) from the genre Indie Pop with a mean tempo of 100.5 BPM (sd = 2.673). The 8 songs were edited using Win Movie Maker (Microsoft, 2021) and ended up having a mean length of 1 minute and 4 seconds (sd =6.22 seconds). Table 2 Show how the songs were divided into 4 conditions (the appendix is available in GitHub as Appendix\_pilot\_study.doc) (Thomasen, 2022).

**Table 2**

Table

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After being presented with each sound clip the participants had to report on the valence of the clip on a scale from -5 to 5, the scale was thoroughly explained before the experiment. Key, either major or minor and type, instrumental or lyrical were the predictor variables and valence were the outcome. I expected the music I major mode would evoke a more positive emotional response compared to music in minor mode, further I expected lyrics to intensify this effect. Figure 1 is a visualization of the data from the pilot study (Thomasen, 2022).

Chart, line chart

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R (R core Team, 2019) and lmerTest (Kuznetsova, Brockhoff and Christensen, 2017) were used to perform a linear mixed effect analysis. Model 1 and 2 were built with the following R syntax:

Model 1, and model 2,

In both models the participant ID was added as a random effect because I expected the participant to have individual baselines.

The results showed participants rated their emotional response more positively when the songs were in major and more negative when the songs were in minor mode . Further the study found that lyrics have an additive effect so both songs in major and minor were rated more positively than songs without lyrics (Thomasen, 2022).

## Participants

For the experiment English-speaking individuals will be recruited, the participants mist be over the age of 18 and must not currently have any neurological or psychiatric disorders, further they must not have suffered from any brain injuries and cannot be taking any psychoactive medication. The experiment will be done as a within-subject design and therefore randomization will be used in the presenting of the stimulus.

## Sample size

When conducting experiments we want a large statistical power, which is the probability of rejecting the null hypothesis. Statistical power is influenced by the effect size, the probability of a type 1 error occurring, also referred to as alpha, and the sample size (Desmond & Glover, 2002). The aim is often a power of 80%, meaning that if the difference truly existed we would detect it in 80 out of a 100 studies (Mumford, 2012). Effect size is often determined based on the experimental design and can therefore be hard to manipulate. Alpha is based on the significance level and the number of hypotheses being tested, however in fMRI studies this is dependent on either the number of regions of interest or the number of voxel you wish to analyze (Desmond & Glover, 2002; Mumford, 2012). In this study 4 ROI’s where determined this led to alpha being adjusted using the Bonferroni correction:

Desomnd & Glover, 2002 estimated the needed sample sizes for fMRI studies to insure a power of 80%. They suggested a minimum of 12 subjects when alpha was 0.05 and 24 subjects if alpha was stricter, further they found the benefit of increased number of participants to lessen after a 100. Therefore a minimum of 24 participants should be sufficient to insure a power of 80% (Desmond & Glover, 2002).

## Stimuli

The Stimuli is picked based on various criteria. The songs will all be lyrical and in English. In previous fMRI studies with participants listening to music, the participants have been presented for 16-34 music pieces varying between 10-30 seconds (Brattico et al., 2011; Khalfa et al., 2005; Mitterschiffthaler et al., 2007). In this study participants will be presented to 24 pieces of music lasting 20 seconds. The pieces will be selected from various genres to make the results more general (Hunter et al., 2008)and to minimize the effect of musical preference on the results (Kreutz et al., 2008)*.* Further the songs are picked based on key and tempo of the melody and sentiment of the lyrics and sorted into 4 conditions (table 1) with 6 songs in each condition. The key and tempo of the melody is some of the features that determines whether the melody is perceived as sad or happy (Gagnon & Peretz, 2003). Songs classified as fast will have a tempo between 120-156 bpm and slow songs will be between 45-60 bpm (Chase, 2020). To determine the sentiment of the lyrics a sentiment analysis will be made on all lyrics (see sentiment\_analysis\_example.ipynb in GitHub). The sentiment analysis example was made using python (Van Rossum & Drake, 2009) and the VADER sentiment analysis tools (Hutto & Gilbert, 2014) on the song My Valentine by Roy Edwin Williams (courtesy of [www.epidemicsound.com](http://www.epidemicsound.com)), which had a tempo of 130 BPM and were in C major. Table

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## Procedure

Upon arrival the participants will be informed about the study protocol and then give informed written consent. Participants were encouraged to ask any question they had before the start. All participants will be required to remove ferromagnetic material. In the fMRI machine participants’ heads will be resting on foam padding and a Velcro strap will be placed across their forehead for comfort and to restrict head movements. The stimuli will be presented to the participant though high-fidelity headphone system (Hall et al., 1999) and at a comfortable sound level around 75-80 db (Brattico et al., 2011; Wehrle et al., 2007). Before the start the participants were encouraged to focus on the music in a relaxing way. The participants will be presented to the 24 song pieces with a delay of 5 seconds between each piece during the fMRI measurement in a randomized order. To indicate the start of the next song pieces a sinusoidal tone would be heard. The fMRI session will last about 10 minutes for each participant.

## Experiment equipment and sampling

The fMRI measurements will be sampled to visualize cortical activity, using an MRI with a 3T field strength. For anatomical localization for all participants high-resolution structural T1-weighted images were obtained. To depict the BOLD contrast during the stimulus presentation a T2\*weighted echoplanar imaging sequence were acquired (Brattico et al., 2011; Khalfa et al., 2005). Some data may be excluded due to stochastic and systematic errors, first after exclusion of this data statistical methods will be used (Wüstenberg et al., 2003).

## Analysis plan

The influence of match between valence in melody and sentiment in lyrics on the liking network will be assessed by statistical comparison of the BOLD signal in the 4 regions of interest: the amygdala, the putamen, the ACC and the hippocampal. There will be conducted a mixed effect analysis using R (R core Team, 2019) and lmerTest (Kuznetsova, Brockhoff and Christensen, 2017) where the outcome variable will be the BOLD signal in each region of interest. The valence of the melody and sentiment of lyrics will be the fixed effect while participant ID is set as the random effect to account for individual differences. The models will be built with the following syntax (the model is an example for the ROI, the hippocampal):

Assumption testing will be run on all models to check they meet the assumptions of homoscedasticity and linearity for linear mixed effect analysis.

# **Data availability**

All future data and materials will be made available upon acceptance of the stage 2 manuscript. Data for the pilot study and other referenced material and data is already available in the following GitHub repository in the ‘data\_and\_material’ folder (<https://github.com/mthomasen/cognitive_neuroscience_of_music_and_language>).

# **Code availability**

All code will be shared publicly upon acceptance of the stage 2 manuscript. Code for the pilot study and other referenced code is already available in the following GitHub repository in the ‘code’ folder (<https://github.com/mthomasen/cognitive_neuroscience_of_music_and_language>).

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# **Author contributions**

The main author, M.S.T., contributed to all sections.

# **Competing interests**

The author declares no knowledge of any competing interests

# **Presentation – Assignment #4**

* Slides (ca. 8), the texts on the slides count as characters