Personality and music

An EEG study on the relation between neuroticism, extroversion and music preferences

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Abstract
This study aims to examine psychophysiological signatures of music preference in relation to personality, using electroencephalograms (EEG). To this end, EEG readings of ten participants were performed and analysed. As stimulus material, six music pieces were used based on previous categorisation that defined three distinct dimensions of psychological attributes in music: arousal, valence and depth. For each dimension, a song was chosen to represent the positive and negative end of the dimension respectively. The two personality factors of extraversion and neuroticism were assessed in participants before EEG measurements. Both correlations and comparisons of means were calculated. To enable the comparison of means, participants were divided into different subgroups regarding the characteristic of either high or low scores in each personality factor. Participants high in extroversion as well as those low in neuroticism showed lower arousal, signs of higher engagement by means of alpha-wave suppression, and rated songs higher than other participants. Positive and negative ends of the music dimensions did not show differences in EEG measurements. Frontal asymmetry did not differ regarding participants ratings for all the six music pieces. Results based on differences in EEG signatures between high and low scores within the personality factors extroversion and neuroticism, indicate that there is a connection between personality and music preference. Further research is needed to better understand the interaction between psychophysiological signatures and music preference.

Keywords: Music, personality, EEG, activation
**Sammanfattning**


*Nyckelord: Musik, personlighet, EEG, aktivering*
Introduction

Already in the womb, a foetus is receptive to sounds and moves in response to auditory stimuli (Ilari, 2002). During all stages of life, music seems to play an important role constantly shaping it by subconsciously influencing our moods, or by active and conscious listening.

Music has, in a psychological context, been described as “a language of the emotions” (Cooke, 1959). Juslin and Sloboda (2010) suggest that music can evoke strong emotions in humans, allowing us to perceive, recognise and be moved by emotions. Furthermore, several studies have shown that influencing emotions is generally the prime motive for listening to music (Juslin & Sloboda, 2010). People for example use music to change, release, and deepen emotions, to enjoy or comfort themselves, or to relieve stress (Juslin & Sloboda, 2010). Listening to music with the intention to regulate emotions may imply that an individual’s personality could have an influence on his or her music preference, as personality to a certain extent determines the frequency of certain emotions (Costa & McCrae, 2003; Eysenck, 1990). In fact, studies have shown that laypersons believe that music preferences reflect important aspects of their own and others personality (Rentfrow & Gosling, 2003, 2006).

Rentfrow and Gosling (2006) examined laypersons beliefs and conducted a two part study. In the first part, 60 undergraduates were asked to interact with each other without direct contact with the instruction to get to know each other. During the first week, the most discussed subject between participants was music (58%), followed by the subjects’ movies (41%) and football (41%). The second part of the study showed that participants could make relatively accurate predictions about a strangers personality only based on that person’s music preferences, indicating that music preference and its related stereotypes influence an observer’s impression of an individual’s values, traits and affect (Rentfrow & Gosling, 2006). Studying the relationship between personality and music preference is therefore interesting and may lead us to better understand how humans interact with music and why music is so meaningful and fulfilling (Juslin & Sloboda, 2010; Rentfrow & Gosling, 2003, 2006).

The influence of personality on music preference was first studied by Cattell and Anderson (1953). The objective of their research was to develop a system using music preference as a diagnostic tool for personality and behavioural disorders, based on the assumption that music preferences provide insight into the unconscious (Cattell & Andersson, 1953; Greenberg et al., 2016; Schäfer & Mehlhorn, 2017). Later research focused instead on quantifiable factors of personality based mainly on the Big Five Factor Model, only varying from a psychometrical viewpoint. A wide array of different personality inventories have been used, for instance the NEO-FFI (NEO-Five Factor Inventory), the Brief Big Five Personality Inventory, HEXACO inventory (Honesty–humility, Emotionality, eXtraversion, Agreeableness, Conscientiousness, Openness to experience), the International Personality Item Pool (IPIP-PI), and the Sensation Seeking Scale (Bonneville-Roussy, Rentfrow, Xu, & Potter, 2013 Brown, 2012; Delsing, Bøt, Engels, & Meeus, 2008; Dunn, delRuyter, & Bouwhuis, 2011; Fricke & Herzberg, 2017; Mills & Vella, 2017; Rentfrow & Gosling, 2003, 2006). The Big Five Factor Model consists of the five factors of personality openness, conscientiousness, extroversion, agreeableness and neuroticism, derived from common language use and established by factor analysis of word lists (Costa & McCrae, 2003; Schäfer & Mehlhorn, 2017).

In contemporary research within the field, the most prevalent approach has been interactionistic meaning that individuals shape their environment to fulfil their psychological needs based on their personality. For example, it is suggested that the personality factor high sensation seeker is more likely to prefer intense music due to their need for intense stimulation. Extroverts in turn would seem to enjoy sociable and enthusiastic music due to their general need for social interaction. Individuals rating high on the personality trait openness are supposed to be more likely to enjoy varied and creative music styles, as well as abstract and complex music pieces that may satisfy their need for cognitive stimulation (Mcdonald & Rentfrow, 2010).
There have been a number of variations within interactionistic approaches. For example, Hall (2005) described the Uses-And-Gratifications approach, proposing that individuals have psychological and social needs and their expected satisfaction creates specific patterns of media use, like music.

Eysenck and Eysenck (1985) stated that the personality factor extroversion reflects individual biological differences in cortical arousal, meaning that highly extroverted individuals have a lower amount of cortical arousal making them less sensitive to stimuli. More highly extroverted individuals therefore have a higher tolerance for arousal in the sympathetic nervous system than less extroverted individuals. Extroverted individuals therefore would theoretically exhibit a higher level of optimal arousal. According to this Theory of Optimal Arousal (Eysenck, 1990; Schäfer & Mehlhorn, 2017), highly extroverted individuals would generally seek out more arousing activities and more arousing music stimuli in order to be able to reach their optimal level of arousal. The music preference of individuals rating high in extroversion could consequently be expected to be inclined towards arousing and engaging music.

Trying to conceptualise music preference into practical categories of broad genres or styles has proved limiting in past research, as appreciation, popularity and understanding of a specific genre category or style may change over time (Greenberg et al., 2016; Mcdonald & Rentfrow, 2010).

Music preference is generally considered synonymous with a person’s overall attitudes towards music (Mcdonald & Rentfrow, 2010). Research regarding this subject focused on stable aspects of these attitudes (Mcdonald & Rentfrow, 2010; Rentfrow & Gosling, 2003). Before these attitudes could be obtained and quantified, there first had to be a structure outlining the differentiations between genre categories, to clarify what constitutes any specific category. To justify the categorisation used in this study, it is useful to make comparisons with previous models.

In a first attempt to categorise music Cattell and Saunders (1954) conducted a factor analysis on participants’ perception of 120 music excerpts with the aim to group them into an underlying structure of music. This statistical method of analysis groups correlated variables into factors to structure and organise data into an understandable and applicable model. This attempt to categorise the participants’ perception of the music pieces resulted in 12 dimensions combining similar aspects in the participant’s description. Cattell and Saunders (1954) refrained from giving specific names to these 12 factors, explaining them as unconscious aspects of personality and temperament.

Several years later, Litle and Zuckerman (1986) created the Musical Preference Scale (MPS). This inventory consisted of 60 exemplary genres under broadly defined categories such as rock or popular music. This work had a notable effect on ensuing research and provided a basis upon which further studies built their design (Dollinger, 1993; Rawlings & Ciancarelli, 1997).

Rentfrow and Gosling (2003) proposed a novel way of categorising music by not basing it on genres, but on unique characteristics that differentiate styles and substyles of music. Participants were asked to identify 14 styles and 66 distinct substyles of music. Results of these identification tasks showed that 97% of the participants recognised the 14 styles but only 7% of the participants could recognise the 66 distinct substyles. The 14 styles were used to collect data from a sample of 1 383 Texas university undergraduates which was then factor-analysed and produced four factors named by Rentfrow and Gosling: “reflective and complex”, “intense and rebellious”, “upbeat and conventional”, and “energetic and rhythmic”. Factor analysis results are illustrated in Figure 1. Based on these four factors, Rentfrow and Gosling (2003) developed the Short Test Of Music Preference (STOMP).
After constructing the STOMP for determining music preference, study participants were asked to fill out personality tests, and correlations between STOMP results and personality factors were calculated (Rentfrow & Gosling, 2003). Among these the correlations of personality factor openness and the two music factors of the STOMP “reflective and complex” and “intense and rebellious” were found to be significantly linked. A negative correlation was shown between the personality factor openness and the STOMP factor “upbeat and conventional”. The personality factor extroversion was correlated to the STOMP factor “upbeat and conventional” and “energetic and rhythmic”. Agreeableness as a personality factor was significantly correlated to the “upbeat and conventional” STOMP factor, the correlations to the “energetic and rhythmic” dimension were smaller but still significant. The conscientiousness personality factor was correlated with the “upbeat and conventional” STOMP factor. The exact correlations are given in Table 1.

Table 1
The significant correlations in Rentfrow and Gosling’s study of 2003.

<table>
<thead>
<tr>
<th>Music dimensions</th>
<th>Extroversion</th>
<th>Neuroticism</th>
<th>Openness</th>
<th>Agreeableness</th>
<th>Conscientiousness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective and complex</td>
<td>n₁ = .44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n₂ = .41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intense and rebellious</td>
<td>n₁ = .18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n₂ = .15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upbeat and conventional</td>
<td>n₁ = .24</td>
<td>n₂ = .15</td>
<td>n₁ = -.14</td>
<td>n₂ = .24</td>
<td>n₁ = .15</td>
</tr>
<tr>
<td></td>
<td>n₁ = .22</td>
<td>n₂ = .08</td>
<td>n₁ = .23</td>
<td>n₂ = .24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n₁ = .19</td>
<td></td>
<td></td>
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<td></td>
<td>n₂ = .08</td>
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<td></td>
<td>n₂ = .09</td>
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</tr>
</tbody>
</table>

In a replicating study by Zweigenhaft (2008), results did confirm the correlations between the personality factor openness and STOMP factor “reflective and complex”, “intense and rebellious”, and “upbeat and conventional”, as well as between the personality factor conscientiousness and the STOMP factor “upbeat and conventional”. These findings would support the hypothesis of an existing underlying structure for the influence of personality on music preference.
Results in other studies have shown larger and similar trends across cultures like Germany, Japan, Netherlands, United Kingdom, and United States (Brown, 2012; Delsing, Bogt, Engels, & Meeus, 2008; Dunn, deRuyter, & Bouwhuis, 2011).

The STOMP was later further differentiated, revised and restructured into a five factor model by Rentfrow, Goldberg and Levitin (2011). This model was then named MUSIC after the first letter in each factor. The five factors were named “Mellow”, “Unpretentious”, “Sophisticated”, “Intense”, and “Contemporary”. Schäfer and Mehlhorn (2017) considered this to be the most elaborate model of music categorisation to date in the context of their meta-analysis.

Using the MUSIC model, Bonneville-Roussy et al. (2013) examined a sample of 254 825 participants selected through the internet, regarding age trends, importance of gender and influence of personality on music preferences. Results showed that personality factor openness was correlated to preferences for “Mellow”, “Sophisticated”, and “Intense” music. This is largely in line with results from the STOMP categorisation model (Rentfrow & Gosling, 2003) where “reflective and complex” as well as “intense and rebellious” music was correlated to the personality factor openness. Furthermore, correlations were found between the personality factor extraversion and “Unpretentious” and “Contemporary” music, the personality factor agreeableness and “unpretentious” music, and personality factor conscientiousness and “unpretentious” music as well as a negative correlation to “intense” music (Bonneville-Roussy et al., 2013). Furthermore,

Rentfrow and Gosling (2003) as well as Schäfer and Mehlhorn (2017) postulated that categorising music by genre constructs is generally parsimonious and pragmatic, if somewhat constrained. A recent meta-analysis by Schäfer and Mehlhorn (2017) points to a level of incoherence within the results of research conducted in the field of personality and music preferences using STOMP or MUSIC as means to categorise music. The factor loadings and effect sizes for both music categorisation models and the correlations with personality factors differ in many cases and seem to sometimes contradict previous findings (Schäfer & Mehlhorn, 2017). Using the raw coefficients of 28 studies, encompassing more than a quarter of a million participants, the total correlations were determined and results were discouraging. The largest combined effect size that was calculated was the personality factor openness to experience and “sophisticated” music \(r = .21\) with a variance of <5% (Schäfer & Mehlhorn, 2017). The authors noted that the predictive value of personality factors for music preference would seem to be limited, which could be due to methodological as well as theoretical problems.

Regarding the methodological objective of first creating a conceptual framework of music to measure music preference, an interesting study attempted to deconstruct a music piece into computer-analysed acoustic features (Daly et al., 2015). The authors aim was to predict music induced emotions by a combination of measuring neural activation and analysing acoustic features. They found confirmatory evidence stating correlations between actual and predicted responses up to \(r = .234 (p < 0.001)\) (Daly et al., 2015). Regression analysis showed that 20% of the variance in the participants music induced emotion could be predicted using neural activity in combination with acoustic features (Daly et al., 2015). There is however a certain loss of qualia in the music following the extreme deconstruction of auditory stimuli.

Another new and promising development was presented by Greenberg et al. (2016). Seventy-six laypersons with no formal music training were instructed to independently rate 102 mixed genre music excerpts based on the laypersons individual perception of 38 perceived psychological attributes provided by Rentfrow et al. (2012) chosen to represent the overall spectrum of musical characteristics as shown in Figure 2. They analysed the results using a principal component analysis and identified three principal components describing for the first time psychological attributes of the music itself instead of conceptualising music through genres or styles. The three components were called arousal, valence, and depth. Positive arousal music was described as intense, forceful, abrasive, and thrilling. Negative arousal music was defined as gentle, calming, and mellow. Music that scored positively on valence was considered to be funny, happy, lively,
enthusiastic and joyful. Negative valence music was described as being depressing and sad. Positive depth music was characterised as intelligent, sophisticated, inspiring, complex, poetic, deep, emotional, and thoughtful. Attributes that loaded on negative depth were party music and had danceable attributes.

Due to the affective nature of the perceived musical attributes in the categorisation of Greenberg et al. (2016), two of the three categories were named partly in accordance with the factors of Russell’s (1980) Circumplex Model of Affect. Russell (1980) plotted the affective dimensions of arousal and valence on two orthogonal axes and placed affective reactions in grades as seen in Figure 3. Affective responses in this model are deconstructed into arousal and valence. Arousal refers to the activation of the sympathetic nervous system, which includes for example sweating, heart rate, tenseness etc. Valence can be defined as the intrinsic positivity or negativity in an affective reaction. A physical response combining elevated heart rate and increase in sweat may be interpreted differently in different emotional contexts. In the context of joy the reaction may be interpreted as eagerness, but in the context of sadness the same reaction may be interpreted as anxiety. In Russell’s (1980) Circumplex Model of Affect, an affective reaction consists of both components arousal and valence (Russell, 1980; Scherer, 2005).
When Schäfer and Mehlhorn (2017) challenged the predictability of music style preferences they argued that people would consume and listen to music according to specific needs in specific situations therefore “utilizing” music. Individuals would listen to music that has proven functional for them in certain situations, which would suggest that any person could develop any pattern of music preference as long as that particular music has proven functional for him or her in a particular situation (Schäfer & Mehlhorn, 2017).

Chamorro-Premuzic and Furnham (2007) distinguished three distinctive factors describing different motivations in the general patterns of how people “use” music. They found that people use music to either regulate emotions, for cognitive or intellectual stimulation, or as background music. Two further studies, one in a European sample and one in an east-Asian sample, found the same factors validating the construct (Chamorro-Premuzic, Swami, Furnham, & Maakip, 2009; Chamorro-Premuzic, Gomà-i-Freixanet, Furnham, & Muro, 2009).

Using music for emotional regulation was correlated with the personality factor neuroticism. A possible explanation is that people that have higher ratings of the personality factor neuroticism, experience emotions more intensely and therefore have a greater need for emotional regulation (Costa & McCrae, 2003; Chamorro-Premuzic Swami, et al., 2009; Chamorro-Premuzic, Gomà-i-Freixanet, et al., 2009). The personality factor extroversion was correlated to using music in the background, which could be explained by the assumption that extroverts are less aroused and use music during other activities to raise their level of arousal to an optimal degree. This is consistent with the Theory of Optimal Arousal (Eysenck & Eysenck, 1985; Eysenck, 1990).

The cognitive and intellectual use of music was correlated with the personality factor openness inferring that people with higher scores for this personality factor might have a higher need for cognitive stimulation (Chamorro-Premuzic & Furnham, 2007). This would be in line with previous research on personality factors describing the personality factor openness as more “cognitive” and more “searching for intellectual stimulation” (Chamorro-Premuzic & Furnham, 2007; Costa & McCrae, 2003; Rentfrow & Mcdonald, 2010).

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One of the most often used approaches to classify personality has been using questionnaires and self-reports (Wache, 2014). Argamon et al. (2005) was among the first to attempt automated estimations of personality, meaning an indirect measurement of personality not reliant on introspection of the individual itself and not influenced by personal biases. Using lexical cues in informal texts written by the participants, machine learning algorithms identified patterns of language predicting the participants scores on extraversion and neuroticism.

Further developments in known technologies as well as new technologies, have provided new tools for automated estimation of personality using psychophysiological markers for emotion and its correlation to personality factors such as electroencephalography, galvanic skin response measurements, and facial landmark trajectory software (Abadi et al. 2015; Alarabi, Wahab, Dzulkifli, & Kamaruddin, 2017; Lisetti & Nasoz, 2004; Wache, 2014).

Lisetti and Nasoz (2004) gathered emotional stimuli based on Russell’s Circumplex Model of Affect, attempting to classify psychophysiological reactions in an affect context, and achieved an 84 % emotion recognition accuracy. Another study by Abadi et al. (2015) employed physiological devices such as electroencephalography (EEG), galvanic skin response (GSR), electrocardiography (ECG), and facial landmark tracking, to compare affect prediction values of video clips in comparison to music clips. Results showed that video clips provided more accurate prediction results than music clips. This could be because visually perceived emotional stimuli might be more easily and quickly interpreted to ensure survival when exposed to a threat, while the complexity of musically evoked emotion might rather be more slowly interpreted. Findings seem to suggest that even complex affective responses can be traced and decoded in psychophysiological reactions. Certain personality factors are more associated with certain emotions, making it possible that personality could be decoded from these emotional and psychophysiological reactions. Like Argamon, Koppel, Fine, and Shimoni (2005), decoding personality by decoding psychophysiological patterns would be an automated measure of personality.

Results of studies examining personality factors regarding different emotional reactions to music were encouraging. Wache (2014) for example found that the personality factor neuroticism is associated with “high arousal” and “low valence”. A negative correlation was found between personality factor openness and stimuli that were more arousing. In addition, a study by Kehoe, Toomey, Balsters, and Bokde (2012) provided results suggesting that extroversion is correlated to “low arousal” and “high valence”. Personality does therefore seem to be traceable through psychophysiological reactions (Abadi et al., 2015; Alarabi et al., 2017; Kehoe et al., 2012; Lisetti & Nasoz, 2004; Wache, 2014). As music often produces an affective response, personality decoding based on psychophysiological reactions to certain music pieces seem promising. This study used EEG to compare psychophysiological reactions to music stimuli.

Non-invasive EEG measures fluctuations within the electrical field at different points on the scalp. This electrical field oscillates at different frequencies. These frequencies can be differentiated into five different frequency bands operating at clearly defined intervals (Niedermeyer & da Silva, 2012). The five frequencies are delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (12-25 Hz), and gamma (>25 Hz). Frequencies of interest for this study however are the three middle frequencies theta, alpha, and beta (Niedermeyer & da Silva, 2012).

Frequencies in the range of 4-8 Hz are commonly referred to as theta-waves (Niedermeyer & da Silva, 2012). Theta-band frequencies have been found to correlate to mental workload and increase with rising degrees of difficulty for a mental operation. They have also been found to act as “carrier frequencies” for cognitive processes. (Klimesch, 1996; O’Keefe & Burgess, 1999; Schack, Klimesch, & Sauseng, 2005).

Alpha-band frequencies occur at 8-12 Hz and are mostly associated with levels of engagement (Niedermeyer & da Silva, 2012; Phurtscheller & Aranibar, 1977). Alpha-waves are most active at states of mental relaxation or meditation, and less active during mental activity or engagement (Phurtscheller & Aranibar, 1977). This means that alpha-wave suppression indicates engagement in a task.
Beta-band frequencies are active at 12–25 Hz and correlate with busy, active or anxious thinking (Zhang et al., 2008). During the execution of planned movements, beta-waves become more active and prominent. Beta-wave frequencies also increase when watching other people’s movements, suggesting that active mirror neurons may be coordinated and traced by beta-wave frequencies (Zhang et al., 2008). It could be supposed that the danceable attribute in the music dimension negative depth would activate mirror neurons due to associations to dancing people in the imagination of the participants. Therefore it is possible that an elevation of beta-wave frequencies would increase in EEG whilst the participants are exposed to the music dimension “negative depth”.

As the music dimension “positive depth” is characterised by the attributes sophistication and intelligence, it is likely that this kind of music is more cognitively demanding and will be accompanied by a higher mental workload. Alpha-wave suppression occurs depending on the level of engagement and may therefore be influenced by music attributes that generally engage each of the different personality factors of extroversion and neuroticism. For persons rating high in the personality factor extroversion this would most likely constitute the music dimensions positive arousal, valence and negative depth due to the happy and social music attributes. For participants scoring high in the personality factor neuroticism, engagement would be expected to be higher in negative arousal, negative valence and positive depth owed to the music dimensions attributes like calmness and mellowness.

Previous research indicates that individuals rating high in the personality factor extroversion seem to prefer lively and energetic music due to it often being used in social contexts (Bonneville-Roussy et al., 2013; Chamorro-Premuzic & Furnham, 2007; Chamorro-Premuzic, Swami, et al., 2009; Chamorro-Premuzic, Gomà-i-Freixanet, et al., 2009; Rentfrow & Gosling, 2003, 2006; Zweigenhaft, 2008). People scoring high in the personality factor neuroticism seem in general more likely to prefer calm and emotional music due to their preference to regulate their emotions using music (Chamorro-Premuzic & Furnham, 2007; Chamorro-Premuzic, Swami, et al., 2009; Chamorro-Premuzic, Gomà-i-Freixanet, et al., 2009; Juslin & Sloboda, 2010).

Frontal asymmetry, also called frontal lateralisation, indicates the difference in activation between the left and right hemisphere of the brain in the frontal cortex and can be detected in EEG. If there is higher activation on one side of the brain than the other, frontal asymmetry or frontal lateralisation is high. If they do not differ, frontal asymmetry is low. Research has shown evidence for approach- or avoidance-tendencies within lateralisation of the brain (Harmon-Jones et al., 2010). Left side lateralisation, is associated with approaching behaviour and positive feelings, while right side lateralisation is associated with avoidance tendencies and negative emotions (Harmon-Jones et al., 2010).

It is therefore plausible that negative ratings for the music stimulus material will be accompanied with right side lateralisation. The assumption can be made that participants rating high in the personality factor neuroticism are more likely to show right side lateralisation, as the personality factor neuroticism is associated with anxiety and depression (McCrae & Costa, 2003). Left side lateralisation is associated with approaching behaviour and positive emotions (Harmon-Jones et al., 2010). It is therefore likely that positive ratings will be accompanied with a higher amount of left side lateralisation.

In general, previous research seems to suggest that personality could have an influence on music preference. So far studies that have investigated the subject mostly used subjective ratings of individuals, a method that could be limited due to personal biases. The aim of this study is to outline and further develop a possible new approach that could be more objective due to its basis in psychophysiological reactions. Eleven hypotheses have therefore been formulated based on previous research in this field and preliminarily tested with a sample of 10 participants using EEG measurements.
Hypotheses
The hypotheses based on previous research in the present study are:

1. Participants rating high in extroversion will display lower theta- and beta-wave activity in EEG.
2. Participants rating high in neuroticism will express higher theta- and beta-wave activity in EEG.
3. Theta-wave activity will be higher in positive depth.
4. Beta-wave activity will be higher in negative depth.
5. Alpha-wave activity will be suppressed in participants rating high in extroversion for positive arousal, valence and negative depth.
6. Alpha-wave activity will be suppressed in participants rating high in neuroticism for negative arousal, valence and positive depth.
7. Participants rating high in extroversion will give higher ratings for positive valence and negative depth.
8. Participants rating high in neuroticism will give higher ratings for negative arousal, valence, and positive depth.
9. Negative ratings will be accompanied by right side lateralisation in the brain.
10. Positive ratings will be accompanied by left side lateralisation in the brain.
11. Participants rating high in neuroticism will be more likely to show right side lateralisation in the brain.
Method

Design
This study used a mixed between-within-subjects design to determine the difference in mean activation in EEG during exposure to different music pieces representing stimuli based on the three music dimensions of arousal, valence and depth.

Participants
Participants were chosen from undergraduate students in psychology at Luleå University of Technology who responded to an E-mail asking for participation in the study. Initially the aim was to select equal numbers of males and females. However, one participant cancelled and had to be replaced. The participants consisted of 10 students, 6 males and 4 females, between the ages of 20 to 37 years with a mean age of $M=24.8$, $SD=5.14$.

Material
Measuring equipment. To measure the fluctuation of the electrical field caused by activation of the outer cerebral cortex, nine electrodes were attached to the scalp of the participant during examination with EEG. An ABM B-Alert 10X, a 9-channel EEG headset with a sampling rate of 256 Hz with bandwidth of 0.1 Hz HPF to 100 Hz LPF for a 10–20 electrode setup was used. The nine electrodes were F3, Fz, F4, C3, Cz, C4, P3, Pz, P4 as shown in Figure 4. Impedance was measured on a four-point scale from no connection to excellent.

Personality factor assessment. To individually assess the two personality factors of extroversion and neuroticism, an adaptation of the International Personality Item Pool (IPIP inventory), the IPIP–NEO was used, which the participants were asked to fill out in advance two weeks before the experiment. The scoring and narrative report routines for this adaption were created by Dr. John A. Johnson, Professor of Psychology at Penn State University, who kindly provided a pencil and paper version for this study. Earlier studies have demonstrated the validity of the IPIP–NEO (Johnson, 2014). Due to the relatively small sample size, no new reliabilities coefficients were calculated. The scores of the personality inventory were subsequently transformed into the dichotomous variables high and low. Any participant whose scores regarding the two personality factors were higher than the respective mean value in the sample, was categorised as high in neuroticism or in extroversion. Those participants who scored under the respective mean

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value of the two personality factors in the sample, were categorised as low in neuroticism or in extraversion.

**Music stimulus material.** A selection of six music pieces was made from the 16 presented exemplary music pieces provided by Greenberg et al. (2016). Two music pieces were chosen to represent stimuli for positive and negative ends for each of the music dimensions arousal, valence and depth. The chosen music pieces were “Rock the Clock” by Ornette Coleman (acid jazz) as a stimulus representing positive arousal and “Children of Spring” by Bruce Smith (adult contemporary) as a stimulus representing negative arousal, “MamboNumeroCinco” by Hilton Ruiz (Latin) as a stimulus representing positive valence and “Just Walk Away” by Karla Bonoff (soft rock) as a stimulus representing negative valence, and “Waxing Moon” by JahWobble (world beat) as a stimulus representing positive depth and “Get the Party Started” by Sammy Smash (Rap) as a stimulus representing negative depth. Each music piece was equalised to ensure a homogeneous auditory quality and volume before the experiment, to minimise risks for possible differences regarding sound quality.

**Procedure**

**Measurements.** The measurement of EEG was carried out in one session with each participant, starting with a 9-minute benchmarking procedure for later data decontamination and post-processing in the software iMOTIONS. During the benchmarking process, the participant conducted three tasks where visual or auditory test stimuli were presented every two seconds followed by a specific reaction task from the participant. After the benchmarking process the EEG measurement was performed. Each participant first received the instructions to relax and close the eyes. Each of the six stimuli for the respective music dimension was then once presented for a time span of exactly 30 seconds. Participants were asked to rate each stimulus according to their enjoyment of it on a Likert-Scale of 1 (very bad) to 5 (very good) immediately after listening to the stimulus, followed by the exposure to the next stimulus. The stimulus material was randomly presented to eliminate any carry-over effects.

**Data-analysis.** Post-processing and decontamination of the EEG data was carried out in the program iMOTIONS from which the data subsequently was exported and analysed in the program CARTOOL. As the EEG data differed in length between participants, the smallest sample was used as a template to standardise the length of the recording. A one and a half second buffer was then removed at either side of the material to further eliminate carry-over effects from the rating tasks between the stimuli. High and low pass filters were used from Abadi et al. (2015) and applied for 3 Hz to 47 Hz. These filters effectively reduced the larger artifacts and any remaining artifacts should be negated by mean calculation.

A fast-fourier transform algorithm was used to change the EEG data into the time-frequency domain, which enabled the subsequent differentiation of the three band-wave frequencies, theta (4–8 Hz), alpha (8–12 Hz), and beta (12–25 Hz).

To determine the mean amount of activation over the three frequency-bands for each stimulus type, mean values for each electrode and subsequently the mean value for all nine electrodes were calculated and entered into the software program Statistical Package for Social Sciences (SPSS). Additionally, frontal asymmetry was calculated in iMOTIONS using data from the frontal electrodes F3 and F4. Both correlations and differences in means were calculated to ascertain any connections between the personality factors of extroversion and neuroticism, psychophysiological reactions to stimulus, and ratings of the songs. To enable the comparison of means after calculating correlations, participants were divided into subgroups representing high and low ratings of each of the two personality factors extroversion and neuroticism. Paired-samples t-tests were used to test for the effects of each music dimension; arousal, valence and depth. Independent sample t-tests were used to test if mean values of band-wave frequencies differed between participants scoring high or low in the personality factor extroversion and neuroticism respectively. Mean values for frontal asymmetry were calculated and compared with
participants’ ratings of the music stimulus material of each dimension using paired-samples t-tests.

**Ethics**

To meet the required ethical standards put forth by the Swedish Ventenskapsrådet (2002), several precautions were taken. All participants were informed in advance of the study’s aim, method and assured of anonymity after which verbal consent was attained and deemed sufficient to continue in the study. Participants were then assigned a number during the filling out of the personality test to enable comparison between their EEG readings and scores in the personality traits extroversion and neurotism. After the statistical analysis was complete, these numbers were rearranged to assure anonymity within the reported material. No information on any of the participants was used for any purpose other than this study.
Results

When comparing mean activation in EEG between stimuli on the positive and negative end of each of the music dimensions arousal, valence and depth, no significant differences were found within each dimension.

Means of ratings were calculated to assess the overall popularity of each music stimulus representing the music dimensions of arousal, valence, and depth (Table 2).

Table 2
Participants mean ratings of stimuli.

<table>
<thead>
<tr>
<th>Stimuli Name</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td></td>
</tr>
<tr>
<td>“Rock the Clock” – Ornette Coleman</td>
<td>1.7</td>
</tr>
<tr>
<td>Positive Depth</td>
<td></td>
</tr>
<tr>
<td>“Waxing Moon” – Jah Wobble</td>
<td>3.1</td>
</tr>
<tr>
<td>Positive Valence</td>
<td></td>
</tr>
<tr>
<td>“Mambo Numero Cinco” – Hilton Ruiz</td>
<td>3</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td></td>
</tr>
<tr>
<td>“Children of Spring” – Bruce Smith</td>
<td>4</td>
</tr>
<tr>
<td>Negative Depth</td>
<td></td>
</tr>
<tr>
<td>“Get the Party Started” – Sammy Smash</td>
<td>2.7</td>
</tr>
<tr>
<td>Negative Valence</td>
<td></td>
</tr>
<tr>
<td>“Just Walk Away” – Karla Bonoff</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Personality factor assessment (IPIP-NEO)

The group mean for neuroticism was $M=59.9$ and for extroversion $M=75.1$ (Maximum score is 120). The participants were categorised as low or high on the respective trait if they scored below or above the mean (Table 3).

Table 3
Number of participants low and high in each personality factor.

<table>
<thead>
<tr>
<th>Neuroticism</th>
<th>Extroversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>5</td>
</tr>
<tr>
<td>Low</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 4:
Individual participant’s categorisation in neuroticism and extroversion.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Neuroticism</th>
<th>Extroversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>8</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>9</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>10</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Ratings and neuroticism

Correlations between the personality factor neuroticism and ratings for each stimulus condition were significant for the conditions of positive depth \( r = -0.645 \), positive valence \( r = -0.630 \), negative depth \( r = -0.737 \). This indicates that the higher participants’ scores in the personality factor of neuroticism, the lower their ratings for the music stimulus.

When using independent-samples t-tests, no significant differences in participants ratings could be detected for the music dimensions arousal and valence. Participants’ ratings for stimuli in the music dimension depth however did display significant differences within the personality factor neuroticism. Participants high in neuroticism rated negative depth stimuli lower \( M=1.80, SD=0.837 \) than participants low in neuroticism \( M=3.60, SD=1.14 \). While equality of variance, as assessed by Levene’s test for equal variance \( (p=0.478) \), could be assumed this was a statistically significant difference, \( t(8)= 2.846, p=0.022, 95\% CI [0.342, 3.258] \). Participants low in neuroticism rated positive depth higher \( M=3.80, SD=0.447 \) than participants high in neuroticism \( M=2.40, SD=1.140 \), which also was statistically significant, \( t(5.202)=2.556, p=0.049, 95\% CI [0.008, 2.792] \). However, in this case the assumption of equality of variance was not met and a test with correction for unequal variances was needed.

Overall, participants high in neuroticism rated songs generally lower \( M=2.3, SD=2.62 \) than participants low in neuroticism \( M=2.3, SD=4.46 \). This was statistically significant \( t(5)=2.058, p<0.05 \). In the personality factor neuroticism, the highest rated stimulus for both groups was the negative arousal stimulus where participants high in neuroticism rated \( M=4.00, SD=1.00 \) and low in neuroticism \( M=4.00, SD=1.00 \).

EEG-results and neuroticism

To determine differences in cerebral activation relating to music stimuli representing the music dimensions of arousal, valence and depth, both correlations and independent-sample t-test were used for each music dimension. The independent-sample t-test compared the mean differences of frequency-band activation within the personality factor neuroticism. Equality of variance was assessed by Levene’s test. When a test neither met the assumption of equal variance nor shows significance or near significance, the results will not be mentioned explicitly as result.

Correlations

For theta-wave activation correlations indicate a strong connection between an increase in theta-wave activation during the conditions of positive arousal, negative depth, negative valence, and the personality factor neuroticism. This would infer that participants with higher scores of the personality factor neuroticism respond to stimuli within the three conditions with increased theta-wave activation (Table 5).

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>0.571*</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>0.494</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>0.241</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>0.629*</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>0.533</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>0.716**</td>
</tr>
</tbody>
</table>

Note: * indicates significance at 0.05; ** indicates significance at 0.01

The alpha-wave activation correlates strongly with the personality factor of neuroticism during all stimulus conditions (Table 6). This strongly indicates that participants scoring higher on the personality factor of neuroticism experience a generally higher level of alpha-wave activation.
than those scoring low on the personality factor neuroticism, inferring a lower level of engagement.

Table 6

*Neuroticism: Correlations of alpha-wave activation with neuroticism in the stimulus conditions.*

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>0.755**</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>0.753**</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>0.695*</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>0.812**</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>0.708*</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>0.704*</td>
</tr>
</tbody>
</table>

*Note: * indicates significance at 0.05; ** indicates significance at 0.01

Similar to theta-wave activation, beta wave activation shows significant correlation with the personality factor of neuroticism in the stimulus conditions: Positive arousal, negative depth, and negative valence (Table 7).

Table 7

*Neuroticism: Correlations of beta-wave activation with neuroticism in the stimulus conditions.*

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>0.571*</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>0.494</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>0.241</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>0.629*</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>0.533</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>0.716**</td>
</tr>
</tbody>
</table>

*Note: * indicates significance 0.05; ** indicates significance at 0.01

**Comparison of means: Arousal and neuroticism.**

In all arousal conditions, the assumption of equality of variance as assessed by Levene’s test was met. Statistically significant differences were found in both theta- and alpha-wave activity for positive and negative arousal stimuli. As shown in Table 8, participants scoring high in neuroticism had higher theta-wave activity in the positive arousal condition than people scoring low in neuroticism. This difference was statistically significant, \( t(8)=3.068, p=0.015 \). On the alpha frequency-band, the mean difference in the positive arousal conditions was also significant, \( t(8)=2.579, p=0.033 \).
The reactions to negative arousal stimuli also showed significant differences. Here participants high in neuroticism showed higher level of theta-wave activity $t(8) = 2.56, p = 0.034$. Alpha frequency-band means provided a statistically significant difference $t(8) = 3.005, p = 0.017$, meaning participants high in neuroticism showed higher alpha-wave activation than others (Table 9). Beta-wave activation showed no significant difference in the positive ($p = 0.177$) and negative arousal conditions ($p = 0.214$).

Comparison of means: Depth and neuroticism.

In the positive depth condition, the assumption of equality of variance was met only for data on theta- and beta-wave activation. Neither theta- nor beta-wave activation was significantly differing between participants high or low in neuroticism. However, theta-wave mean activation shows a near significant difference between participants high and low in neuroticism of $t(8) = 2.218, p = 0.057$. When equal variance is not assumed, alpha-wave mean activation also shows a nearly significant difference $t(5.128) = 2.41, p = 0.059$ (Table 10).
The assumption of equal variances was not met in the negative depth condition for data on the frequency-bands theta and alpha, but was met for the frequency-band beta. The difference in means for beta-wave activation was not statistically significant, however, $t(8)=1.898, p=0.094$. When examining the results if equal variance is not assumed, both theta-waves, $t(4.871)=2.673, p=0.045$, and alpha-waves, $t(4.681)=3.104, p=0.029$, produced statistical significances (Table 11).

Table 11
**Neuroticism: Negative depth stimuli mean frequency values.**

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Neuroticism</th>
<th>Low Neuroticism</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>$M=45.21, SD=16.36$</td>
<td>$M=24.60, SD=5.43$</td>
<td><strong>20.61</strong></td>
<td>0.63 - 40.59</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>$M=108.32, SD=58.56$</td>
<td>$M=23.62, SD=17.14$</td>
<td><strong>84.69</strong></td>
<td>13.09 - 156.30</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>$M=18.62, SD=3.90$</td>
<td>$M=11.80, SD=7.03$</td>
<td>6.82</td>
<td>-1.47 - 15.11</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed

**Comparison of means: Valence and neuroticism.**

With Positive valence music no statistically significant differences in theta- or beta-wave bands emerged. For alpha-wave data the assumption of equal variances was not met ($p=0.027$). When equal variance was not assumed, participants scoring high on neuroticism showed significantly higher alpha-wave activity than participants with lower scores of neuroticism $t(5.038)=2.949, p=0.032$ (Table 12).

Table 12
**Neuroticism: Positive valence stimuli mean frequency values.**

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Neuroticism</th>
<th>Low Neuroticism</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>$M=46.90, SD=21.79$</td>
<td>$M=27.84, SD=5.41$</td>
<td>19.05</td>
<td>-4.10 - 42.21</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>$M=116.76, SD=56.87$</td>
<td>$M=36.95, SD=20.66$</td>
<td><strong>79.81</strong></td>
<td>10.40 - 149.21</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>$M=20.50, SD=3.82$</td>
<td>$M=15.28, SD=6.68$</td>
<td>5.23</td>
<td>-2.71 - 13.16</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat Equal variance not assumed

For negative valence music, the theta frequency-band data did not meet the assumption of equal variances ($p=0.005$). Statistically significant results were present for alpha, $t(8)=2.990, p=0.017$, and beta $t(8)=2.415, p=0.042$, frequency-bands, meaning that participants with higher scores of neuroticism showed higher alpha- and beta-wave activation in the negative valence condition (Table 13).
Table 13

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Neuroticism</th>
<th>Low Neuroticism</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>M=44.94, SD=17.90</td>
<td>M=26.33, SD=6.21</td>
<td>18.60</td>
<td>-3.24</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>M=110.95, SD=63.33</td>
<td>M=24.32, SD=13.67</td>
<td><em>86.62</em></td>
<td>19.81</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>M=20.58, SD=4.30</td>
<td>M=11.80, SD=6.91</td>
<td><em>8.78</em></td>
<td>0.39</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed

Participants scoring high and low in neuroticism seem to display similar activation patterns in theta- and alpha-wave frequencies (Figure 5). In alpha-waves, both seem to display vertexes in positive valence and positive depth. This could suggest that participants were most engaged in the positive depth condition, and least engaged in the positive valence condition. Theta waves display less obvious vertexes but doo seem to reflect similar activation. The lines connecting the mean activation values in the graphs were added to visualise the higher psychophysiological general activation in participants high in neuroticism.

Figure 5. Mean activation in the three EEG frequency-bands in the music conditions for participants scoring high and low on neuroticism.
When plotting frequency band activation for both high and low scores in the personality factor neuroticism, a clear difference in activation can be observed (Figure 5). The pattern is in general similar, displaying similar vertexes especially in alpha-wave activation, but the overarching activation seems to be higher for participants scoring high in the personality factor neuroticism. It is important to note that not all results are significant however.

High activation in electrodes P3, POZ, and P4 shows alpha-wave activity predominantly originates in posterior and occipital regions of the brain. The location of the three electrodes P3, POZ, and P4 are shown in Figure 4. Additionally, participants scoring high in neuroticism exhibit a higher oscillation rate in the amount of alpha-waves (Figure 6).

Results concerning the ratings of the music stimulus show negative correlations for the stimulus conditions of positive depth, positive valence, and negative depth, as well as a general tendency for participants scoring more highly in the personality factor of neuroticism to rate stimulus lower.

When examining the reactions to music stimuli in reference to neuroticism, results show a positive correlation in theta- and beta-waves for the stimulus condition positive arousal, negative depth and negative valence, as well as a positive correlation for alpha waves and all stimulus conditions. Regarding the comparison of means, both theta- and alpha-wave activations differ significantly between participants high and low in neuroticism. Activation of the alpha frequency-band displayed the most significant results in difference of activation between high and low levels of neuroticism.

Ratings and Extroversion

Correlations between the personality factor extroversion and ratings for the specific stimulus types were found for the stimulus conditions positive arousal \((r=0.583)\), positive valence \((r=0.637)\), and negative depth \((r=0.552)\). This indicates that participants scoring higher on extroversion also rated the music excerpts of positive arousal, positive valence and negative depth higher.

When using independent-samples t-tests to compare ratings of the music with positive valence between those with high and low scores in neuroticism, the assumption of equality of variance was met as assessed by Levene’s test for equal variance \((p=0.024)\). The mean ratings of music with positive valence for participants high in extroversion were higher \((M=3.67, SD=0.816)\) than for participants low in extroversion \((M=2.00, SD=0.816)\). The mean difference \((M_{\text{diff}}=1.667)\) was statistically significant, \(t(8)=2.162, p=0.013, 95\% CI [0.451, 2.882]\). When
comparing participants’ ratings of music with negative depth within the personality factor extroversion, a nearly significant difference was seen: participants high in extroversion rated negative depth higher (\(M=3.33, SD=1.366\)) than people low in extroversion (\(M=1.75, SD=0.500\)) \(M_{\text{diff}}=1.583, t(8)=2.185, p=0.06, 95\% [0.088, 3.254]\). Similar to participants high in neuroticism, those low in extroversion (\(M=2.21, SD=3.43\)) rated songs lower in general than participants high in extroversion (\(M=3.2, SD=3.43\)). Here, too, the results were significant, \(t(5)=2.068, p>0.05\).

**EEG-results and extroversion**

Using the same method as for the personality factor neuroticism, both correlations were calculated and independent sample t-tests were used to test the mean differences of frequency-band activation, relating to music stimuli within the personality factor extroversion. Equality of variance was assessed by Levene’s test. When a test neither met the assumption of equal variance nor shows significance or near significance, the results will not be mentioned explicitly.

**Correlations**

Correlations between the personality factor of extroversion and theta-wave activation during the different stimulus conditions showed a significant correlation during the positive depth condition (Table 14). This would indicate that participants scoring high in the personality factor extroversion exhibited higher theta wave activation during the stimulus condition negative depth.

**Table 14**  
*Extroversion: Correlations of theta-wave activation with extroversion in the stimulus conditions.*

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>0</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>-0.139</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>0.654*</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>-0.210</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>0.314</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>-0.202</td>
</tr>
</tbody>
</table>

Note: * indicates significance 0.05; ** indicates significance at 0.01

The stimulus conditions positive arousal, negative arousal, and negative depth produced a negative correlation to the personality factor of extroversion (Table 15), indicating that participants scoring higher in extroversion showed lower alpha-wave activation in the three stimulus conditions.

**Table 15**  
*Extroversion: Correlations of alpha-wave activation with extroversion in the stimulus conditions.*

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>-0.584*</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>-0.610*</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>-0.472</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>-0.625*</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>-0.375</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>-0.495</td>
</tr>
</tbody>
</table>

Note: * indicates significance 0.05; ** indicates significance at 0.01

As in the case of the personality factor neuroticism, the coefficients for theta- and beta-wave activation mimic each other (Table 5, 7, 14, 16). The result indicates that theta- and beta-wave
activation resembles one another and that participants scoring high in extroversion show higher beta-wave activation in the stimulus condition positive depth.

Table 16
Extroversion: Correlations of beta-wave activation during stimulus conditions and the personality factor extroversion

<table>
<thead>
<tr>
<th>Stimulus condition</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Arousal</td>
<td>0</td>
</tr>
<tr>
<td>Negative Arousal</td>
<td>-0.139</td>
</tr>
<tr>
<td>Positive Depth</td>
<td>0.654*</td>
</tr>
<tr>
<td>Negative Depth</td>
<td>-0.210</td>
</tr>
<tr>
<td>Positive Valence</td>
<td>0.314</td>
</tr>
<tr>
<td>Negative Valence</td>
<td>-0.202</td>
</tr>
</tbody>
</table>

Note: * indicates significance 0.05; ** indicates significance at 0.01

Comparison of means: Arousal and extroversion
The assumption of equal variances was met for alpha frequency-band data in the positive arousal condition. This was the only statistically significant difference with positive arousal stimuli, $t(8)=2.390$, $p=0.044$, inferring that participants scoring high in extroversion displayed lower activation of alpha-waves than participants low in extroversion (Table 17).

Table 17
Extroversion: Positive arousal stimuli mean frequency values.

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Extroversion</th>
<th>Low Extroversion</th>
<th>Mean Difference</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>$M=31.76$, $SD=12.06$</td>
<td>$M=36.77$, $SD=11.26$</td>
<td>5.02</td>
<td>-12.50</td>
<td>22.54</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>$M=36.910$, $SD=27.19$</td>
<td>$M=103.56$, $SD=61.19$</td>
<td><em>66.65</em></td>
<td>2.35</td>
<td>130.96</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>$M=15.92$, $SD=9.44$</td>
<td>$M=16.96$, $SD=4.24$</td>
<td>1.04</td>
<td>-9.26</td>
<td>11.34</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed

In the negative arousal condition the assumption of equal variance was met for alpha frequency-band data. Participants high in extroversion showed statistically significant lower levels of alpha-wave activation, $t(8)=2.636$, $p=0.03$ (Table 18).

Table 18
Extroversion: Negative arousal stimuli mean frequency values.

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Extroversion</th>
<th>Low Extroversion</th>
<th>Mean Difference</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>$M=30.37$, $SD=9.69$</td>
<td>$M=41.05$, $SD=18.12$</td>
<td>10.68</td>
<td>-9.4</td>
<td>30.75</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>$M=41.42$, $SD=29.32$</td>
<td>$M=113.47$, $SD=57.86$</td>
<td><em>72.05</em></td>
<td>9.03</td>
<td>135.08</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>$M=16.89$, $SD=10.76$</td>
<td>$M=18.55$, $SD=2.70$</td>
<td>1.66</td>
<td>-9.63</td>
<td>12.95</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed
Comparison of means: Depth and extroversion

The assumption of equal variances was not met for alpha-wave activation data in the positive depth condition music. The only significant difference in activation was alpha-wave activation in the negative depth condition, \( t(8)=3.029, p=0.016 \), showing lower alpha-wave activation in participants high in extroversion (Table 19 and 20).

Table 19
Extroversion: Positive depth stimuli mean frequency values.

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Extroversion</th>
<th>Low Extroversion</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theta</td>
<td>( M=39.40, SD=14.55 )</td>
<td>( M=31.11, SD=9.45 )</td>
<td>8.29</td>
<td>-9.01 – 25.60</td>
</tr>
<tr>
<td>Alpha</td>
<td>( M=85.88, SD=51.35 )</td>
<td>( M=30.54, SD=19.73 )</td>
<td>*55.34</td>
<td>-22.77 – 133.45</td>
</tr>
<tr>
<td>Beta</td>
<td>( M=16.62, SD=4.51 )</td>
<td>( M=19.70, SD=12.25 )</td>
<td>3.08</td>
<td>-11.91 – 18.08</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed

Table 20
Extroversion: Negative depth stimuli mean frequency values.

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Extroversion</th>
<th>Low Extroversion</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theta</td>
<td>( M=41.47, SD=18.51 )</td>
<td>( M=30.52, SD=13.68 )</td>
<td>10.95</td>
<td>-12.37 – 34.27</td>
</tr>
<tr>
<td>Alpha</td>
<td>( M=117.25, SD=65.47 )</td>
<td>( M=31.78, SD=22.07 )</td>
<td>*85.47</td>
<td>20.39 – 150.55</td>
</tr>
<tr>
<td>Beta</td>
<td>( M=16.61, SD=1.18 )</td>
<td>( M=14.27, SD=8.46 )</td>
<td>*2.34</td>
<td>-6.51 – 11.20</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed

Comparison of means: Valence and extroversion

There were no statistically significant differences between those high and low in extroversion in the valence conditions. Alpha-waves did show a nearly significant difference \( t(8)=2.271, p=0.053 \) in the negative valence condition. This was the case when the assumption of equality was met (Table 21 and 22).

Table 21
Extroversion: Positive valence stimuli mean frequency values.

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Valence</th>
<th>Low Valence</th>
<th>Mean Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theta</td>
<td>( M=43.44, SD=26.06 )</td>
<td>( M=33.32, SD=11.32 )</td>
<td>10.11</td>
<td>-17.12 – 37.35</td>
</tr>
<tr>
<td>Alpha</td>
<td>( M=124.81, SD=64.31 )</td>
<td>( M=44.88, SD=23.78 )</td>
<td>*79.93</td>
<td>-18.13 – 177.99</td>
</tr>
<tr>
<td>Beta</td>
<td>( M=18.54, SD=2.42 )</td>
<td>( M=17.46, SD=7.55 )</td>
<td>1.08</td>
<td>-8.08 – 10.23</td>
</tr>
</tbody>
</table>

Note: * indicates significance; fat indicates equal variance not assumed
Table 22

*Extroversion: Negative valence stimuli mean frequency values.*

<table>
<thead>
<tr>
<th>Band-wave</th>
<th>High Valence</th>
<th>Low Valence</th>
<th>Mean Difference</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theta</strong></td>
<td>M=39.19, SD=16.51</td>
<td>M=33.26, SD=16.72</td>
<td>5.93</td>
<td>-18.84</td>
<td>30.71</td>
</tr>
<tr>
<td><strong>Alpha</strong></td>
<td>M=113.36, SD=78.81</td>
<td>M=37.16, SD=27.98</td>
<td>76.2</td>
<td>-1.17</td>
<td>153.57</td>
</tr>
<tr>
<td><strong>Beta</strong></td>
<td>M=18.91, SD=2.12</td>
<td>M=14.37, SD=8.88</td>
<td>4.54</td>
<td>-4.78</td>
<td>13.85</td>
</tr>
</tbody>
</table>

*Note: * indicates significance; fat indicates equal variance not assumed

*Figure 7.* Mean activation in the three EEG frequency-bands in the music conditions for participants scoring high and low on extroversion.

As for the personality factor neuroticism, frequency activation trends in theta- and alpha-wave bands show that participants high and low in extroversion display similar activation patterns except in the case of beta-wave activation (Figure 7). Alpha-waves seem to display vertexes in positive valence and positive depth.

Significant positive correlations between the ratings and scores on the personality factor extroversion were found for positive arousal, positive valence, and negative depth. Comparison of means further adds that positive depth was rated higher by participants scoring high on the personality factor of extroversion. Participants scoring high in extroversion in general rated the stimulus material higher.
Results do show that alpha-wave activation during stimulus conditions of positive and negative arousal as well as negative depth, negatively correlates to extraversion. Theta- and beta-wave activation showed a positive correlation to the stimulus condition positive depth. The independent-samples t-tests further indicate that, participants high in extroversion seem to display lower levels of both theta- and alpha-wave activation than participants low in extroversion. Comparison of means shows that alpha band-wave activation demonstrated the most reliable differences in mean activation. Figure 7 displays the mean activation of all participants with high and low ratings of extroversion.

\[ \text{Figure 7. Mean alpha-band activation profiles for each electrode for participants high and low on extroversion.} \]

Similar to participants scoring high in neuroticism, participants low in extroversion showed higher activation in alpha-waves originating in the posterior occipital regions as can be seen in activation of P3, POZ, and P4 electrodes (Figure 8). Additionally, participants scoring low in extroversion displayed a higher oscillation rate in the amount of alpha-waves.

**Frontal asymmetry**

Frontal asymmetry was not indicated by the results in any condition with any dependent variable. This considerably weakens hypotheses 9, 10, and 11.
**Discussion**

When comparing cerebral-activity between participants with high and low levels of neuroticism and extroversion, a difference can be surmised to exist in the material.

Correlations show an inverse relation regarding alpha-wave activation between the personality factors of extroversion and neuroticism. The personality factor of neuroticism displayed positive, and strong correlations for all stimulus conditions with alpha-wave activation whereas extroversion displayed negative correlations which was significant for the stimulus conditions positive arousal, negative arousal, and negative depth. Participants high in neuroticism generally display higher activation in all frequency-bands. As people high in neuroticism in general are associated with higher arousal, the higher level of frequency-activation in participants scoring high in neuroticism could be interpreted as an indication of their higher level of psychophysiological arousal. Presented graphical illustrations of the alpha-wave activation for all participants reflect a clear tendency for higher amplitude in activation and higher amplitude oscillation for participants scoring high in neuroticism. This could be interpreted as a tendency for only brief engagement by participants high in neuroticism in the stimulus material, followed by attentional resources being more easily diverged and scattered. The generally more rapid oscillation in alpha wave frequencies, as shown in Figure 7, could however also suggest higher psychophysiological arousal.

For individuals high in neuroticism, the results indicate a higher magnitude of alpha-wave suppression in the positive depth condition. Interestingly, this was combined with slightly lower theta-wave activation, indicating that positive depth engaged listeners but seemed to simultaneously lower mental workload. A possible explanation is that the attribute qualities of music with positive depth, like for instance deep, dreamy, and thoughtful attributes, act as a sort of focusing lens for participants high in neuroticism, refocusing attention towards the music stimuli itself instead of the surrounding social setting.

Participants high in extroversion displayed lower mean activity for both theta- and alpha-waves (Figure 7). Additionally, participants high in extroversion displayed signs of lower beta-wave activation when exposed to all stimuli except for the positive depth condition. This may indicate active concentration considering the concurrent alpha-wave suppression, meaning that participants high in extroversion were more mentally activated by the stimulus.

For participants high in neuroticism, higher levels of both theta- and alpha-waves were on large significant. Differences in beta-waves were significant in fewer cases but showed a higher mean activation for participants high in neuroticism further strengthened by correlations showing a significant correlation for the stimulus conditions positive arousal, negative depth, and negative valence. Due to beta-waves being associated with anxious or busy thinking, results could indicate certain coherence with previous research results on personality factors. As aforementioned, the personality factor neuroticism is associated with higher prevalence of negative emotions like depression, sadness or anxiousness.

The conclusion could be drawn that participants with higher scores on neuroticism experienced more anxious feelings during the three stimulus conditions positive arousal, negative depth, and negative valence. The abrasive, aggressive and forceful attributes (Figure 2) of the positive end of the arousal dimension could have activated participants scoring high in neuroticism, raising their relative level of psychophysiological arousal leading to a negative affect reaction. Positive arousal did not however receive significantly lower ratings.

In the case of the negative depth condition, the danceable and party-music attributes of the music cannot clearly be said to relate to any anxiousness-inducing effects. It is possible that this sample size had relatively small overlap between the personality factors extroversion and neuroticism, meaning that participants scoring high on neuroticism also scored relatively low on extroversion. If this were the case, the relatively social attributes of negative depth could raise
associative social pressure creating a negative affect reaction. In this case, neuroticism and the ratings for this stimulus condition correlated negatively.

Negative valence is characterised by attributes such as sadness, depression, and emotionality (Figure 2). The connection between a higher amount of beta-wave activity and music with generally sad, depressed and anxious attributes is to a certain degree clear. Ratings by participants did not present a significant correlation, meaning that it is not possible to determine if there was a negative affect reaction.

It seems clear that above described interactions do carry potential for a more comprehensive framework of music preference in the question; Do our psychophysical reactions to music determine peoples liking and rating of music? Future research should focus on further determine and evaluate interactions that could prove important in the effort to determine if personality influences music preference.

The first hypothesis of this study stated that participants high in extroversion would display lower theta- and beta-wave activity, and the second hypothesis of this study stated that participants high in neuroticism would express higher theta- and beta-wave activity. Results suggest that the first and the second hypotheses could be partially correct, even though not all differences were significant. To evade attributing a connection when there is none, both hypotheses will have to be rejected at present. However, the indications of underlying effects should not be wholly discarded as methodological issues could have influenced the results and a larger and more comprehensive study could provide the necessary insights.

When comparing activation during stimuli on the positive and negative ends of a music dimension respectively using a paired samples t-test, no significant values could so far be reported. This test did however not account for personality factors and, considering the previously indicated differences between high and low levels of neuroticism and extroversion, the distinct possibility of type-two erroring must be considered. When presenting the mean activation values graphically, tendencies for higher beta-wave activation in the positive depth condition could be observed, the same tendencies for the negative depth condition however, could not be shown. Participants high in extraversion and low in neuroticism, demonstrated these tendencies. For theta-wave activity, no such statements could be made.

The third hypothesis of this study stated that theta-wave activity would be higher in the positive depth condition and the fourth hypothesis stated that beta-wave activity would be higher in the negative depth condition. The conclusion at present is that, both the third and fourth hypothesis of this study must be rejected, with the annotation, that positive depth does seem to cause higher activation in the theta- and beta frequency-band in participants with higher scores in extroversion as well as in participants scoring lower in neuroticism due to the positive correlation between extroversion and theta- and beta-wave activation during positive depth stimulus condition. Participants scoring low in neuroticism showed a near significant higher level of mean theta-wave activation. Implications could be that with the alpha-wave suppression shown in comparison of means in the positive depth condition, music in the positive end of the depth dimension stimulates participants high in extraversion or low in neuroticism and engages them. On the other hand, the high activation in the beta frequency-band alone could also indicate anxious or busy thinking, leading to the conclusion that participants did not enjoy this music. Mean ratings from participants low in neuroticism for the positive depth condition were statistically significantly higher, further strengthened by the negative correlation between neuroticism and ratings for the stimulus condition positive depth. Throughout the data, the separate subgroups of participants scoring high in extroversion and scoring low in neuroticism have to a certain extent behaved similar. This could strengthen the first assumption that participants high in extroversion and low in neuroticism were more cognitively stimulated by the music and enjoyed the music.

Previous research has indicated that participants high in extraversion use music more often in a background and social context. An assumption could therefore be that music that expresses
social, arousing and positive attributes, will engage participants high in extraversion. Similarly, participants high in neuroticism were shown to be more likely to use music to regulate emotions. Considering results of previous research that show that people high in neuroticism are more aroused in general it would be reasonable to assume that people high in neuroticism would prefer music with calming or mellow attributes to decrease arousal and emotional intensity and therefore exhibiting higher engagement. The fifth hypothesis stated that alpha–wave activity would be suppressed in participants high in extraversion in the positive arousal, positive valence and negative depth conditions. The sixth hypothesis stated that alpha–wave activity would be suppressed in participants high in neuroticism in the negative arousal, negative valence and positive depth conditions.

Extroversion and alpha–wave activation correlated negatively for the stimulus conditions positive arousal, negative arousal, and negative depth. This indicates that participants with higher scores of extraversion were more engaged by said stimulus conditions. This leaves the fifth hypothesis only partially correct, as positive valence does not display low alpha–wave activation, and therefore it must be rejected.

The relatively high amount of alpha–waves in the positive valence condition directly contradicts the fifth hypothesis of the study. It could be explained, however, by extraversion being associated with using music in a background context (Chamorro-Premuzic & Furnham, 2007). They may therefore automatically switch from the active listening mode to passive background listening by habit, when perceiving the fun, lively, and social attributes in music with positive valence. As the characteristics of music with positive valence are happy and joyful, and not particularly cognitively demanding, this dimension could also simply ease participants’ relative tension. As this trend is more present in participants low in extraversion and participants high in neuroticism, the happy attributes in music with positive valence may have helped to regulate emotions by releasing tension leading to lowered engagement.

As neuroticism correlates positively in all stimulus conditions, hypothesis six must also be rejected.

The seventh hypothesis stated that participants high in extraversion would give higher ratings for music with positive valence and negative depth. The eighth hypothesis stated that participants high in neuroticism would give higher ratings for negative arousal, negative valence, and positive depth music.

The seventh hypothesis would seem to be confirmed, as extraversion correlated positively with ratings in positive valence and negative depth. The eighth hypothesis however cannot be confirmed. Neuroticism showed negative correlation with ratings for positive depth, positive valence, and negative depth, directly contradicting hypothesis eight. It must therefore be rejected.

The ninth hypothesis stated that negative ratings would be accompanied by right side lateralisation in the brain. The tenth hypothesis stated that positive ratings would be accompanied by left side lateralisation in the brain. The eleventh hypothesis stated that participants high in neuroticism would be more likely to show right side lateralisation in the brain.

In this study no lateralisation effect was obtained with any music excerpt. This would imply that the eighth, ninth and tenth hypotheses at present would have to be rejected.

For alpha–wave suppression, however, results seem contradictory. If participants high in extraversion are more likely to use music in a background context, alpha–wave suppression would more likely be less active when these individuals listen to music. In the positive valence condition this would seem to be true, as participants high in extraversion then had higher levels of alpha–waves than in other conditions. It would seem not to be true in the negative depth condition however, as alpha–wave activation was generally lower constituting higher engagement.

Considering that it could be possible for one song to have positive loadings of two attributes simultaneously, there is a risk that there would be a certain distortion of data. The risk for this
occurrence was however thought to be low due to the clear-cut definitions provided by Greenberg et al. (2016)

Testing for differences in reactions to the positive and negative end of the music dimensions provided no statistically significant results. Due to stimuli being selected from the end points of a music spectrum, differences in psychophysical reactions could be expected to a certain degree. Greenberg et al. (2016) set these dimensions as broadly defining characteristics with clear cut definitions for each dimension. It therefore follows that negative stimuli should display inverted tendencies to positive stimuli. This does not seem to be the case, however. It is possible that the robustness of structural indications for underlying psychological attributes in music is not as firm as indicated, and that they could be called into question. This study however does not present enough data to definitively state such assumptions.

The aim of this study was to begin to outline a possible new approach in the field of research on how personality influences music preference. With a sample of 10 participants, the psychophysiological reactions to music were determined using EEG and then compared within factors of personality.

The music categorisation used in this study was presented by Greenberg et al. (2016). In this proposed model, the music dimensions of arousal, valence, and depth were based on affective attributes and named in consideration to the Circumplex Model of Affect by Russell (1980). As personality decoding, by use of EEG measurement of affective responses, uses the same Circumplex model of affect (Abadi et al., 2015; Alarabi et al., 2017; Wache, 2014), there seems to be cohesiveness between these two building blocks. It would seem that this could provide a coherent base to build theoretical arguments on. It could however be equally cohesive and stringent to use the method of Daly et al. (2015). Their approach was a frequency analysis of the music stimulus material which, when combined with EEG readings of participants listening to the stimulus material, explained 20% of variance in music emotions calculated by regression analysis (Daly et al., 2015). Closely analysing frequency fluctuations in stimulus material and connected EEG readings could also provide a good foundation for future research. An advantage that the affect approach does seem to have is the research backing the decoding of personality using psychophysiological traceable affective reactions. Seeing that music often induces an affective reaction, the expected reaction could be compared with peoples’ personality. For instance, stimulus in the music dimension arousal, could be expected to induce an affective reaction that shows higher relative arousal. Comparing the actual reactions of people in a particular personality factor with the expected reactions may provide results that could be linked to music preferences.

This study used a mixed between-within-subjects design, where music dimension was the within-subjects factor and personality was the between-subject factor, while frequency-band EEG activation and participants’ ratings were dependent variables. Correlations were calculated using the raw scores of each participants personality test. Unfortunately, the low number of participants did not allow for factorial ANOVA:s to investigate interactions with sufficient power. Therefore, as a preliminary investigation of possible effects, the independent-samples t-tests were used in order to outline a possible future method of analysis.

Most large studies using EEG for examining behavioural determinants have so far used a 64 or more electrode EEG. The EEG equipment (ABM-10X) used in this study had only 9 electrodes permitting easier testing for preliminary results. Due to EEG-data being very complex, the data in this study was reduced to means in the interest of examining general trends in activation. This constitutes a certain simplification of data but is helpful in concentrating statistical interactions in an attempt to find tendencies that could, at a later point in time, provide grounds for further study.

After calculation of correlations, the data from the personality test was categorised into a dichotomous variable before applying the independent-samples t-test. This process gave a simple data structure and was performed to arrange factors for later ANOVAs. However, due to the lack of power, the ANOVAs were never carried out.
There is a strong risk for discarding a connection when there possibly is one in this study due to the small sample size and the relatively simple measuring equipment. The risk of attributing a connection when there is none is relatively low, due to the controlled nature of the experiment and testing method.

The sample had a near equal gender distribution and an age span of 17 years. Preliminary findings of this study therefore should represent an acceptable degree of demographic external validity.

Furthermore, within the significant results of the t-tests, equality of variance is not always present, leading to a poorer degree of internal validity.

In general, the data does not provide a strong enough statistical base upon which one could build solid theories regarding the influence of personality upon music preference. This is certainly mainly due to the simplification of data, the sample size, and equipment simplicity. This study does however outline a possible new approach to an interesting and important topic. Future research should further examine the relationship between personality, psychophysiological reactions towards music, and music preferences with larger and more comprehensive studies.
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