International Journal of Psychophysiology 142 (2019) 25–32

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Don't drink and chill: Effects of alcohol on subjective and physiological reactions during music listening and their relationships with personality and listening habits

Katrin Starcke[a,*], Richard von Georgi[a], Titta Marianne Tiihonen[b], Klaus-Felix Laczika[c], Christoph Reuter[d]

[a] SRH University of Popular Arts, Potsdamer Straße 188, 10738 Berlin, Germany
[b] Aarhus University, Nørrebrogade 44, 8000 Aarhus C, Denmark
[c] Medical University of Vienna, Währinger Gürtel 18-20, 1090 Wien, Austria
[d] University of Vienna, Spitalgasse 2, 1090 Wien, Austria

ARTICLE INFO

Keywords:
Chills
Music
Alcohol
Electrodermal activity
Heart rate
Personality
Music listening habits

ABSTRACT

Recent research indicates that favorite music can induce chills and alters physiological reactions. People frequently listen to music when they drink alcohol, for example in bars or discotheques. Alcohol has numerous effects on emotions, peripheral physiological and neural reactions. We investigated whether alcohol intake influences chill experiences and physiological reactions during music listening. 39 participants took part in the study and were tested twice: Once in a sober condition and once when they had drunken alcohol. Participants listened to two pieces of music in each of the two conditions: A favorite self-selected song and a control-song that was selected by the research group. Participants had to indicate when they experienced a chill and electrodermal activity and heart rate were measured during music listening. In addition, participants filled out questionnaires concerning the big five personality dimensions, music listening habits and general chill experiences. Results indicate that participants experienced most chills when they were sober and listened to their self-selected song. Electrodermal activity was highest when participants were sober. In addition, alcohol intake led to a dedifferentiation in heart rate activity. After alcohol intake, participants had similar heart rates, no matter whether they listened to their self-selected song or to the control-song. Extraversion was negatively related with physiological reactions, while openness to experiences was positively related with physiological reactions. Music listening habits also showed various relationships with chill experiences and physiological reactions, while general chill experiences did not. We conclude that alcohol intake reduces subjective chill experiences during music listening and alters the physiological reactions to music. Music listening habits and personality seem to influence these effects.

1. Introduction

Chills are intense sensations that can occur during music listening and other aesthetic experiences. Chills are experienced during particularly intense moments and are usually transient in nature. Participants describe chills as shivers down the spine, lump in the throat, tears, goose pimples, trembling, sexual arousal, etc. (Kunkel et al., 2008). For laboratory research, participants are frequently asked to provide a self-selected piece of music that has elicited chills in the past. Results indicate that participants experienced more chills when they listened to their self-selected musical piece, compared with a control-piece (e.g., Laeng et al., 2016). Recent research has elucidated the physiological reactions during listening to highly favorable music. One study investigated subjective and physiological reactions when participants listened to self-selected musical pieces compared with control-pieces (Salimpoor et al., 2009). Participants listened to musical clips and continuously rated whether they evaluated a passage as neutral, high in pleasure, low in pleasure, or whether it induced a chill. During the self-selected favorite piece, participants showed physiological reactions that differed from those during the control piece. While reactions during the control-piece did not show much variation, reactions during the self-selected piece varied dependent on participants' ratings. During the passages that included chills, heightened electrodermal reactions, heightened heart rate, and heightened respiration frequency, lowered finger temperature and lowered blood volume pulse amplitude

* Corresponding author.
E-mail address: Katrin.Starcke@srh.de (K. Starcke).

https://doi.org/10.1016/j.ijpsycho.2019.06.001
Received 21 January 2019; Received in revised form 24 April 2019; Accepted 3 June 2019
Available online 04 June 2019

were measured. The aforementioned study demonstrated that chill experiences were also accompanied by pupillary dilation (Laeng et al., 2016). Another study investigated the temporal dynamics of physiological responses during heartbreak-songs (Tsai et al., 2014). All participants listened to popular heartbreak-songs which were composed of sad verses and highly emotional choruses. The songs were selected by the research group. Results indicated that electrodermal activity increased at two times during the heartbreak-songs: Once at the end of the verse directly prior to the beginning of the chorus, and once during the beginning of the chorus. Finger temperature decreased during the first verse and rose from the beginning of the chorus. The authors concluded that two kinds of reactions exist during music listening. One that is anticipative in nature and one that corresponds to the concrete rewarding experience. Thus, listening to music does not only affect subjective experiences, but can also lead to peripheral physiological arousal which is an indicator of sympathetic nervous system activity. On the brain level, a similar pattern was found. Self-selected favorite musical pieces elicited chills that were related to activation of the mesolimbic reward system, as detected with positron emission tomography (Blood and Zatorre, 2001). A more recent study combined positron emission tomography and functional magnetic resonance imaging in a similar research design (Salimpoor et al., 2011). Immediately prior to the chill experience, activity of the dorsal striatum (nucleus caudatus) increased, whereas during the concrete chill experience activity of the ventral striatum (nucleus accumbens) increased. The same reaction pattern was found for the release of the neurotransmitter dopamine. In a follow-up study, participants listened to pieces of music they did not know before while their brain activity was measured (Salimpoor et al., 2013). After each of the pieces, participants had to state how much money they would spend for the respective piece of music. Results indicate that participants' activation of the ventral striatum (nucleus accumbens) was the best predictor for spending money. Further predictors were activation of the dorsal striatum (nucleus caudatus) and the functional connectivity between auditory cortices, amygdala, and ventromedial prefrontal regions with the nucleus accumbens. Thus, listening to music induces subjective, peripheral physiological, neural, and behavioral reactions.

People frequently listen to music when they drink alcohol, for example in bars, discotheques or when attending concerts and festivals. Alcohol is proposed to enhance emotional state and to impair attentional processes, at least under certain conditions (review in Sayette, 2017). Alcohol also affects peripheral physiological processes and brain reactions. In healthy participants, an acute dose of alcohol administration led to increased heart rate and decreased heart rate variability (Buckman et al., 2015). Alcohol crosses the blood-brain barrier and can affect brain function directly. In healthy participants, alcohol administration led to an increased release of dopamine in the ventral striatum (Urban et al., 2010). In alcohol dependent participants, acute alcohol administration also led to increased dopamine release in the right ventral striatum (Yoder et al., 2016). Thus, alcohol affects emotion, and leads to altered peripheral physiological and brain reactions similar as favorite music does. The question arises whether alcohol consumption enhances chill experiences and physiological reactions during music listening or whether intoxication interferes with the experience of chills and dampens physiological reactivity when listening to music. So far, only one study (a dissertation thesis) has investigated the effects of alcohol on music listening (Reinhardt, 2011). The dissertation thesis contains two studies; a field study and a laboratory study. In both studies, the effects of alcohol on music preferences were examined. In the field study, participants were asked concerning their music preferences during a party in 30 min intervals over 3 h. The amount of alcohol consumed was assessed via self-report and the blood alcohol concentration was estimated. Participants were able to select pieces of music they want to hear and to regulate the amplitude. Results indicated that participants preferred higher amplitudes and higher tempi in the course of alcohol consumption. In addition, participants preferred more simple genres in the course of alcohol consumption, such as Schlager music and electro music. In the laboratory study, one group was investigated in a sober condition, while the other group had drunken alcohol. Again, the alcohol group preferred music that was high in amplitude, high in tempo, and simple in nature in the course of alcohol consumption, whereas the control group did not show alterations in preference. In addition, respiration frequency, heart rate and electrodermal activity were higher in the alcohol condition than in the control condition. The current study does not investigate musical preference after alcohol consumption, but chill-experiences and physiological reactions during songs that were selected prior to alcohol consumption.

Recent research indicates that musical preferences are related to personality traits. For example, preferences for reflective and complex music (e.g., classical, jazz, blues), are related to the personality trait openness to experiences. Preferences for upbeat and conventional music (e.g., pop, country) are related to the personality traits extraversion, agreeableness, and conscientiousness. Preferences for hard musical styles (e.g., punk, rock) are negatively related to the personality trait conscientiousness (e.g., Bonneville-Roussy et al., 2013; Delsing et al., 2008; George et al., 2007; Rentfrow and Gosling, 2003).

However, research on physiological reactions towards music in relation to the listeners' personality is sparse. One study investigated physiological and endocrine reactions towards techno music versus classical music and their relationship with personality traits (Gerra et al., 1998). Results indicated that listening to techno music led (among others) to an increase in heart rate and blood pressure, and to increased secretion of the stress hormones noradrenaline and cortisol. The secretion of noradrenaline showed relationships with the personality traits harm avoidance and novelty seeking. In a more recent study (Park et al., 2013) participants listened to happy, sad, and fearful music while their brain activation was measured with functional magnetic resonance imaging. In addition, personality traits were assessed. Results indicated that brain reactions in the basal ganglia, insula and orbitofrontal cortex during the happy music condition were related to neuroticism. Brain reactions during fearful music in the right amygdala were marginally related to extraversion. In another recent study, participants listened to a self-selected favorite musical piece and a musical piece that they explicitly dislike (Montag et al., 2011). Results indicated robust activation in the ventral striatum, the dorsal striatum and the insula when listening to the favorite piece. More importantly, activation of the ventral striatum was modulated by the personality trait self-forgetfulness (a subscale of the personality trait transcendence). Thus, participants react differently on different types of music and even towards their self-selected favorite piece of music, dependent on their personality. In the current study, we assessed personality dimensions of the NEO-five factor inventory (Costa and McCrae, 1989) in order to explore relationships between personality traits and subjective and physiological reactions in our experimental conditions.

In detail, we examined chill-experiences and physiological reactions in a self-selected piece of music and a piece of music that was selected by the research group in a sober condition versus after alcohol intake. During music listening, the number of chills and electrodermal activity and heart rate were measured. we measured the number of chills and the peripheral physiological parameters electrodermal activity and heart rate. In addition, we assessed participants' music listening habits and their personality with questionnaires. In accordance with recent studies, we expected a higher number of chills and higher physiological reactions during listening to the self-selected piece of music compared with the control-piece. In addition, we expected that alcohol intake influences subjective chill experiences and physiological reactions during music listening. To the best of our knowledge, no studies on that topic exist so far. Therefore, our hypothesis is undirected. On the one hand, alcohol may cause a sensitization of chill relevant systems due to the increased release of dopamine, which could lead to a higher number of chill reactions (additive effect). On the other hand, alcohol may lead to reduced attentional processes and may consequently reduce dopamine reactivity towards specific musical passages (interfering effect). Furthermore, we assessed personality traits and music listening habits in order to describe the sample and to explore relationships between questionnaire data and subjective chill experiences and physiological reactions.

2. Participants

Overall, 39 participants who occasionally drink alcohol were enrolled in the study. Participants were recruited via an advertisement at the University of Vienna, and by word of mouth. Each participant was tested twice: Once in a sober state and once after drinking alcohol. The order of the two conditions was permutated by random. Participants were between 20 and 61 years old (mean = 28.03, *SD* = 7.93). Approximately half of them were male ($N = 19$) and the other half were female ($N = 20$). Most of the participants were students. Participants were briefed about study participation on a separate day prior to participation. All participants were asked whether they suffered from current or previous alcohol use disorder, current or previous substance use disorder (exceptions were caffeine and tobacco), whether they suffered from any heart disease, and whether they currently took any medication or take medication regularly. Female participants were asked whether they were pregnant. If they answered one of these questions with “yes”, they were excluded from the study. In the written informed consent, participants confirmed with their signature that they did not meet any of the exclusion criteria. In addition, participants were asked to refrain from alcohol at least 8 h prior to participation. This was confirmed via breathing test. One participant was excluded from participation because of alcohol intake prior to the experimental session. The study was approved by the ethics committee of the Medical University of Vienna. A physician supervised all data collections. After completing the experiment, participants were thanked for participation and debriefed again about the goal of the study. However, the experiment did not include any deceive (such as a cover-story), so the debriefing was in accordance with the briefing procedures.

3. Methods

3.1. Music stimuli and measurement of chills

All participants were exposed to two pieces of music in each of the two conditions. One piece was selected by the research group: “What a wonderful world” performed by Eva Cassidy (life version with a duration of approximately 5.5 min, referred to as “control-song” in the following). The other piece was a piece that was selected by the participants and that was described as a favorite piece of music which elicited at least one chill previously (referred to as “chill-song” in the following). The chill-songs that were chosen by the participants can be seen in Table 1. The chill-songs lasted approximately 4.79 min on average. Electrostatic headphones were used for music exposure (Koss ESP/950). Amplitudes were normalized so that the volume was approximately the same for all participants and all pieces of music. Participants were instructed to press a button, whenever they experienced a chill during music listening.

Table 1
Chill-songs that were chosen by the participants.

Title	Interpret/composer
The best of times	Sage Francis
Groundation	Silver Tongue Show
Dream is collapsing	Hans Zimmer (Soundtrack “Inception”)
Stay with me	Clint Mansell
The last man	Clint Mansell
Flashback	Fat Freddy's Drop
Inside my brain	La Phaze
Hier kommt Alex	Die Toten Hosen
Comptine d'un autre été	L'après midi (Soundtrack “Amélie”)
Right where it belongs	Nine Inch Nails
Always	Bon Jovi
Livin' for the city	Stevie Wonder
Liebestraum	Franz Liszt
Time to kill	Overkill
Dust	Wino and Conny Ochs
Svetlina	Elica Todorova and Gahl Sasson
Tourdion	Rolf Lislevand
Bei mir bist du schön	Zarah Leander
I mecht landen	Maria Bill
Time	Hans Zimmer (Soundtrack “Inception”)
The elder scrolls main theme medley	Morrowind, Oblivion, Skyrim
You enjoy myself	Phish
Irgendwann bleib I dann dort	Austropop
Der Zwerg	Franz Schubert
Nothing else matters	Metallica
The past recedes	John Frusciante
Beleza do ouro	Renata Rosa
Parce mihi domine	Jan Garbarek
Deep water	Luke Danfield
Country falls	Husky rescue
Surrounding love	Accu
Requiem d-minor K626	Wolfgang Amadeus Mozart
The moon is distant from the sea	David Childs
Dusk falls upon the temple of the serpent on the mount of sunrise/ Cast down the heretic	Nile

Some of the songs were chosen by more than one participant.

3.2. Alcohol intake and measurement

In the alcohol condition, participants had to drink Vodka (43% alcohol) mixed with orange juice. They were asked to drink ad libitum. The amount of Vodka consumed varied from 6 to 18 cl. The level of alcohol was measured with an alcohol tester that measures alcohol concentration via breathing (Dräger Alcotest 7410). The test determines blood alcohol concentration in ‰ with an accuracy of ± 0.05‰. The alcohol breathing test was assessed 15 min after alcohol intake and after the experimental procedure. The blood alcohol concentration ranged from 0.4 to 1.5‰ (mean = 0.7‰, *SD* = 0.2‰).

3.3. Measurement of physiological parameters

During music listening, participants' electrodermal activity and heart rate were recorded with the NeXus-10 Mark II system and Bio Trace + ® software (Mind Media). The device also offered a button which could be pressed when experiencing a chill. Two Ag/AgCL electrodes (one placed on the forefinger and one placed on the middle finger of the participants' non-dominant hand secured with Velcro straps) were used to measure electrodermal activity. Results were measured and analyzed in microsiemens. A finger clip (placed on the ring finger of the participants' non-dominant hand) was used to assess heart rate via photoplethysmography. Results were measured and analyzed in beats per minute. Out of the 39 participants, 27 had complete physiological datasets which could be included in the analysis.

3.4. Music listening habits, general chill experiences, and personality

The purposes why participants listened to music in their everyday life were assessed with the Inventory for the assessment of Activation and Arousal modulation through Music (IAAM; von Georgi et al., 2006; von Georgi, 2013). The questionnaire consists of 55 items that are answered on a five-point Likert scale ranging from 0 (never) to 4 (very frequently). The dimensions relaxation, cognitive problem solving, reduction of negative activation, fun stimulation, and arousal modulation are assessed.

The Music Related Chill Questionnaire (MRCQ; Kunkel et al., 2008) was used to assess habitual chill reactions to music. The questionnaire consists of 84 that are answered on a four-point Likert scale ranging from 1 (does not apply) to 4 (completely applies). Chill experiences are measured on the subdimensions positive reactivity, physiological reactivity, motor reactivity, social cognitive reactivity, general disorientation, social and emotional defense. In addition, participants were asked whether they learned to play an instrument (yes, no), whether they currently make music (yes, no), and whether they experience or experienced chills when listening to music on a six-point scale ranging from 1 (yes, occasionally) to 6 (no, I do not know this experience).

Personality was assessed with the German version (Borkenau and Ostendorf, 1993) of the NEO Five-Factor-Inventory (NEO-FFI; Costa and McCrae, 1989). The questionnaire consists of 60 items that are answered on a five-point Likert scale ranging from 1 (does not apply) to 5 (completely applies). The personality traits neuroticism, extraversion, openness for experiences, agreeableness, and conscientiousness are measured.

3.5. Design and procedure

The experiment was conducted in a cross-over repeated measures design. Half of the participants listened to the two musical pieces in a sober state; and approximately two weeks later after drinking alcohol. The other half of participants listened to the two musical pieces after they drank alcohol; and approximately two weeks later in a sober state.

In the first experimental session, participants filled out the questionnaires prior to the experimental procedure. In the alcohol condition, participants drank alcohol ad libitum. No time limit was set for drinking. The breathing test was assessed 15 min after finishing drinking. Electrodes were attached, and earphones were placed. Recording of the physiological parameters started. After a one-minute baseline measurement, participants listened to their favorite chill-song or the control-song respectively. After that, a baseline physiological recording of 1 min started again, and thereafter participants listened to the respective other song. Finally, the breathing test was assessed again. In the sober condition, the experiment directly started without the intake of alcohol. The breathing test was only assessed once in order to ensure that participants were sober.

3.6. Statistical analysis

The physiological raw data were saved with the Bio Trace + ® software. They were exported to Microsoft Excel and mean values were calculated for each physiological parameter for each participant in each of the four conditions. Mean values were manually transferred to SPSS, version 22 (IBM, Armonk, NY, USA). Results for the number of chills, electrodermal activity and heart rate were analyzed each with a mixed 2 × 2 ANOVA (sober/alcohol; chill-song/control-song). Partial eta squared (η_p^2) was used as effect size. Pearson correlations were performed in order to calculate the relationships between age, questionnaire data, and participants' blood alcohol concentration with the number of chills and the physiological data. In order to examine effects of gender, we re-analyzed our dependent variables (the number of chills, electrodermal activity and heart rate) with a mixed 2 × 2 × 2 ANOVA (sober/alcohol; chill-song/control-song) and included gender (male/female) as an additional factor.

Table 2
Results of music listening habits and personality.

Variable	Mean	*SD*	Range
IAAM Relaxation	22.46	9.06	6–42
IAAM Cognitive problem solving	18.89	11.18	1–40
IAAM Reduction of negativ activation	18.44	9.79	4–43
IAAM Fun stimulation	27.60	8.15	8–51
IAAM Arousal modulation	15.58	10.48	0–38
MRCQ Positive reactivity	15.54	2.87	8–20
MRCQ Social and emotional defense	12.29	2.78	7–18
MRCQ Physiological reactivity	16.39	2.82	9–23
MRCQ Motor reactivity	12.72	2.59	7–18
MRCQ Social cognitive reactivity	14.62	2.42	9–20
MRCQ Disorientation	15.51	2.90	9–22
NEO FFI Neuroticism	26.54	8.70	12–45
NEO FFI Extraversion	29.77	5.88	21–42
NEO FFI Openness	32.02	5.34	22–42
NEO FFI Agreeableness	28.63	6.53	11–43
NEO FFI Conscientiousness	33.61	7.28	18–49

IAAM = Activation and Arousal modulation through Music; MRCQ = Music Related Chill Questionnaire; NEO FFI = NEO Five-Factor-Inventory.

4. Results

4.1. Sample description

Out of the 39 participants, 28 reported that they have learned or played an instrument. Out of them, 18 reported that they currently make music. Only one participant reported that he or she never had a chill experience. Results for music listening habits and personality are summarized in Table 2.

4.2. Subjective chill experiences

Participants experienced most chills when they were sober and listened to their chill-song (mean = 8.10, *SD* = 7.0). They experienced fewer chills during the same song when they had drunken alcohol (mean = 5.05, *SD* = 5.19). When listening to the control-song, they experienced few chills when they were sober (mean = 2.72, *SD* = 5.04) and when they had drunken alcohol (mean = 2.33, *SD* = 3.86). Results are shown in Fig. 1. The ANOVA (Table 3) displays significant results for the main effects and the interaction effect.

4.3. Physiological reactions

Participants had highest electrodermal levels when they were sober and listened to the control-song (mean = 5.22, *SD* = 2.97) and they had also high electrodermal levels when they were sober and listened to their chill-song (mean = 4.30, *SD* = 2.37). When they had drunken alcohol, they had lower electrodermal levels when they listened to the control-song (mean = 3.94, *SD* = 2.48) and they had even lower electrodermal levels when they listened to their chill-song (mean = 2.97, *SD* = 2.08). Results are shown in Fig. 2. The ANOVA (Table 4) displays

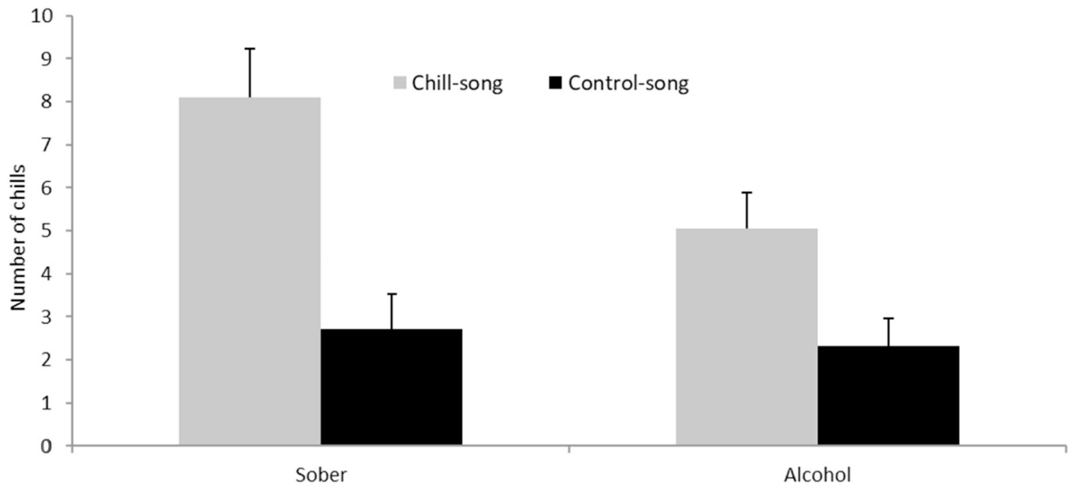

Fig. 1. Number of chills during music listening in a sober state and after drinking alcohol. Error bars represent standard errors.

Table 3
Main effects and interaction effect for the number of chills.

Variable: Subjective	*F*	*MSE*	*df*	*p*	η_p^2
Chill-song versus control-song	19.09	33.52	1, 38	< 0.001	0.33
Sober versus alcohol	4.83	23.84	1, 38	< 0.05	0.11
Chill-song versus control-song × sober versus alcohol	7.94	8.73	1, 38	< 0.01	0.17

Table 4
Main effects and interaction effect for the electrodermal activity.

Variable: Electrodermal activity	*F*	*MSE*	*df*	*p*	η_p^2
Chill-song versus control-song	24.18	0.98	1, 26	< 0.001	0.48
Sober versus alcohol	7.70	6.01	1, 26	< 0.01	0.23
Chill-song versus control-song × sober versus alcohol	0.02	0.75	1, 26	0.88	0.001

significant results for the main effects, but not for the interaction effect.

Heart rate was highest when participants had drunken alcohol and listened to their chill-song (mean = 86.57, *SD* = 16.75) and heart rate was also high when participants were sober and listened to their chill-song (mean = 86.28, *SD* = 13.15). Heart rate was lowest when participants were sober and listened to the control-song (mean = 80.87, *SD* = 14.72) and medium when they had drunken alcohol and listened to the control song (mean = 85.87, *SD* = 18.48). Results are shown in Fig. 3. The ANOVA (Table 5) shows significant results for the main effect chill-song versus control-song, but not for the main effect sober versus alcohol. However, the interaction effect between chill-song versus control-song × sober versus alcohol was significant.

4.4. Relationships between general chill experiences, music listening habits, and personality with chills, and physiological reactions

We performed correlations between the number of chills, electrodermal activity levels and heart rate with the music listening habits (measured with the IAAM), general chill experiences (measured with the MRCQ), and personality (measured with the NEO FFI). Results are shown in Table 6. The IAAM showed relationships with the subjective chill experiences and physiological reactions during music listening. The personality traits extraversion and openness to experiences showed relationships with the physiological reactions during music listening. The MRCQ was hardly related to the parameters assessed during music listening.

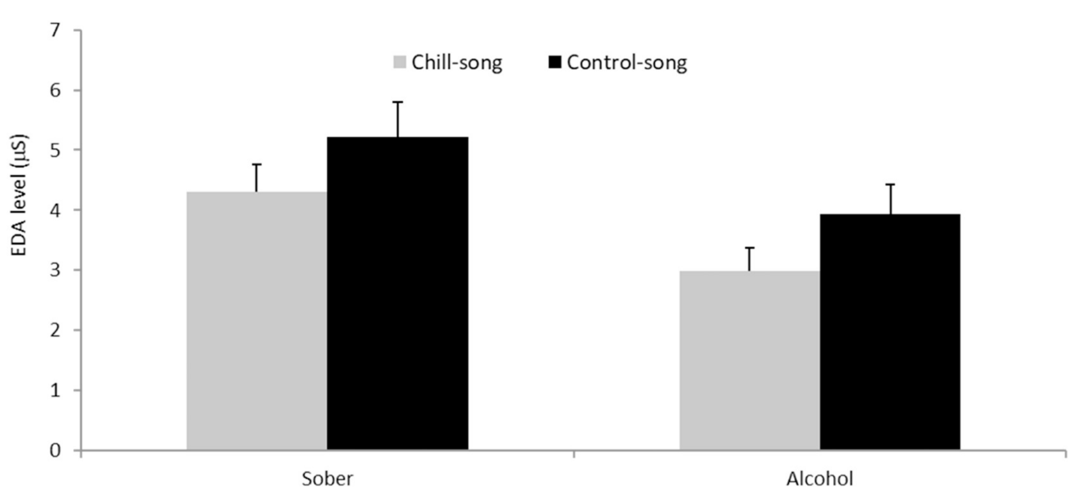

Fig. 2. EDA levels during music listening in a sober state and after drinking alcohol. Error bars represent standard errors. EDA = electrodermal activity; µS = microsiemens.

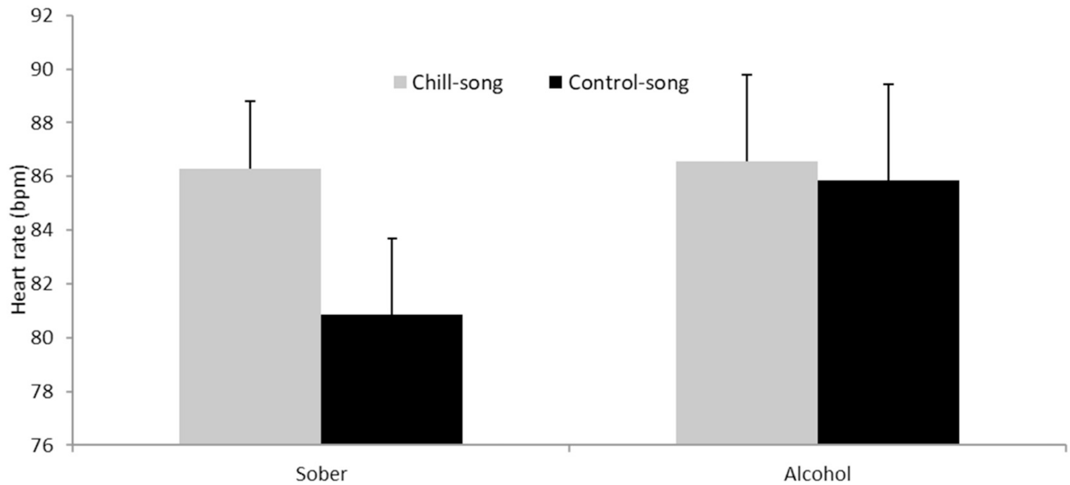

Fig. 3. Heart rate during music listening in a sober state and after drinking alcohol. Error bars represent standard errors. Bpm = beats per minute.

Table 5
Main effects and interaction effect for the heart rate.

Variable: heart rate	*F*	*MSE*	*df*	*p*	η_p^2
Chill-song versus control-song	7.83	32.16	1, 26	< 0.01	0.23
Sober versus alcohol	0.42	451.03	1, 26	0.52	0.02
Chill-song versus control-song × sober versus alcohol	8.60	17.42	1, 26	< 0.01	0.25

4.5. Influences of blood alcohol concentration, age, and gender on chills, and physiological reactions

Finally, the influences of blood alcohol concentration, age and gender on chills and physiological reactions were tested. Blood alcohol concentration was unrelated with subjective chill experiences and physiological measures in the alcohol conditions (all *p*s > 0.05). Age was also unrelated with subjective chill experiences and there was a single negative correlation with the electrodermal activity during the control song after alcohol intake ($r = -0.40$, $p < 0.05$). Thus, high electrodermal activity was associated with younger age in this specific condition. Regarding potential gender effects, the additional mixed 2 × 2 × 2 ANOVA analyses led to identical decisions regarding hypotheses testing. Thus, the direction of effects due to the experimental manipulations remained stable.

5. Discussion

Results indicate that participants experienced most chills when they were sober and listened to their favorite chill-song. Physiological reactions also differed between the sober state and after alcohol intake. Electrodermal activity during music listening was higher in a sober state than after alcohol intake. Heart rate was overall higher after alcohol intake than in the sober state, but after alcohol intake, no differentiation between the favorite chill-song and the control-song occurred. More precisely, in a sober state heart rate was higher when listening to the favorite chill-song in comparison with the control-song, while after drinking, heart rate was approximately the same, no matter whether participants listened to their favorite chill-song or to the control-song. Music listening habits were related to the number of chills and electrodermal reactions during music listening. The personality dimensions extraversion and openness to experiences were related to electrodermal reactions and heart rate during music listening.

In accordance with previous studies (Laeng et al., 2016; Salimpoor et al., 2009), the number of chills and the physiological reactions were higher when listening to the favorite chill-song compared to a control-song. Alcohol intake modulated both, the experience of chills and the physiological reactions during music listening. Alcohol intake dampened the experiences of chills. Thus, instead of an additive effect we found an interference between musical chills and alcohol intake. Even personal favorite chill-songs induced fewer chills when drunk. We

Table 6
Significant relationships between subjective and physiological reactions during music listening and questionnaire data that measure music listening habits, general chill experiences and personality.

	IAAM: relaxation	IAAM: reduction negative affect	IAAM: fun stimulation	IAAM: arousal modulation	MRCQ: disorientation	NEO FFI: extraversion	NEO FFI: openness
Number of chills: chill-song sober		$r = 0.34$ $p < 0.05$	$r = -0.36$ $p < 0.05$				
Number of chills: control-song sober	$r = 0.44$ $p < 0.01$	$r = 0.48$ $p < 0.005$			$r = 0.35$ $p < 0.05$		
EDA: chill-song sober				$r = 0.50$ $P < 0.01$		$r = -0.48$ $p < 0.01$	
EDA: control-song sober				$r = 0.51$ $p < 0.01$		$r = -0.48$ $p < 0.01$	$r = 0.40$ $p < 0.05$
EDA: control-song alcohol							$r = 0.40$ $p < 0.05$
Heart rate: chill-song sober						$r = -0.50$ $p < 0.01$	
Heart rate: control-song sober						$r = -0.44$ $p < 0.05$	

EDA = electrodermal activity; IAAM = Activation and Arousal modulation through Music; MRCQ = Music Related Chill Questionnaire; NEO FFI = NEO Five-Factor-Inventory.

hypothesized two potential effects of alcohol on chill experiences prior to the investigation. First: Favorite music might have led to dopamine release within the mesolimbic reward system, and alcohol may also have led to dopamine release within the mesolimbic reward system. Therefore, alcohol might have enhanced the experiences of musical chills. Second: alcohol might have led to impairments of attention and might have interfered with the experience of chills. Our results clearly support the second assumption. Alcohol interfered with chill experiences. Electrodermal reactions were in line with the subjective chill experiences. They were lower after alcohol intake which might be due to reduced attentional processes. Results for heart rate activity were different, but still in line with previous studies. A recent study showed that alcohol leads to heightened heart rate (Buckman et al., 2015), and this was also shown in the current study. In the course of this increase, the differentiation between reactions towards the favorite chill-song compared with reactions towards the control-song disappeared. After alcohol intake, heart rate did not vary, no matter whether participants listened to the self-selected chill-song or the control-song. Thus, alcohol intake does not only influence the acute musical preference (see Reinhardt, 2011), but also influenced subjective and physiological reactions towards favorite songs. Future studies should investigate in more detail whether distracting the attention away from the musical stimulus is really the underlying factor that dampened chill experiences after alcohol intake.

Our exploratory analysis of music listening habits and personality in relation to chill experiences and physiological reactions revealed interesting results. The reasons why participants listen to music in their free time were related to the number of chills experienced during music listening and the electrodermal activity. Music listening to reduce negative affect was positively related with the number of chills and music listening to stimulate fun was negatively related to the number of chills. Thus, frequent chill experiences during music listening might be an underlying factor why people experience reductions in negative affect. However, a causal conclusion cannot be drawn here, because results are only correlational in nature. Future studies should determine whether chill experiences are the underlying factor that reduce negative affect and whether this is a main purpose for music listening. Contrary, fun stimulation was negatively related to the number of chills. Thus, listening to music because of fun stimulation appears to have other underlying mechanisms than chill experiences. Arousal modulation was related to electrodermal reactions during music listening. As electrodermal reactions are considered a peripheral signal of arousal, this is not surprising. Nevertheless, it is interesting that participants who report that they listen to music in their free time because they want to modulate their arousal are those individuals who show enhanced electrodermal arousal when they listen to music. The personality trait extraversion was negatively related to electrodermal reactions and heart rate during music listening. This is in line with the theory of Eysenck (Eysenck, 1967), stating that extraverted people show fewer signs of arousal when confronted with external stimuli relative to introverted people. Recent research showed that this is also true for musical stimuli. Park et al. (2013) demonstrated that brain reactions within the amygdala were marginally negatively related to extraversion. In the current study, openness to experiences was positively related to electrodermal reactions. A previous study showed that the secretion of noradrenaline during listening to techno music was related to the personality trait novelty seeking (Gerra et al., 1998) which shares some features with the trait openness to experiences.

The current study has some limitations that should be addressed here. First, the amount of alcohol consumed differed between participants and consequently the blood alcohol concentration differed. This procedure was chosen due to ethical reasons as participants should have been allowed to drink ad libitum and not be forced to consume a certain amount of alcohol. Second, some data loss occurred during the physiological measurements which reduced the number of participants with complete physiological data. Third, although participants did not report any difficulties in task performance, we cannot rule out that they sometimes forgot to press the button when they experienced a chill. This problem might have occurred particularly under the influence of alcohol and might have led to a distortion of the subjective data. Physiological data should have been unaffected by this source of distortion.

6. Conclusion

People frequently enjoy music and alcohol at the same time (in bars, discotheques, or concerts), but results indicate that the experience of chills is dampened through alcohol intake. Thus, if one really aims to experience chills during music listening it would be more advantageous to be sober. However, music listening in social contexts probably has other reasons than seeking chill experiences. In bars or discotheques, the social contacts are more important than the background music. In concerts, seeing the idols on stage might be more important than experiencing musical chills. Chill experiences might be experienced predominantly when one is completely focused on the music, for example at home, with earphones, and: sober.

Funding source

No external funding.

We declare that we have no conflict of interest.

The study procedures were carried out in accordance with the Declaration of Helsinki.

Results have not been published or submitted elsewhere.

References

Blood, A.J., Zatorre, R.J., 2001. Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. Proc. Natl. Acad. Sci. 98, 11818–11823.

Bonneville-Roussy, A., Rentfrow, P.J., Potter, J., 2013. Music through the ages: trends in musical engagement and preferences from adolescence through middle adulthood. J. Pers. Soc. Psychol. 105, 703–717. https://doi.org/10.1037/a0033770.

Borkenau, P., Ostendorf, F. (Eds.), 1993. NEO-Fünf-Faktoren Inventar (NEO-FFI) nach Costa und McCrae. Hogrefe, Göttingen.

Buckman, J.F., Eddie, D., Vaschillo, E.G., Vaschillo, B., Garcia, A., Bates, M.E., 2015. Immediate and complex cardiovascular adaptation to an acute alcohol dose. Alcohol. Clin. Exp. Res. 39, 2334–2344. https://doi.org/10.1111/acer.12912.

Costa, P.T., McCrae, R.R. (Eds.), 1989. The NEO-PI/NEO-FFI Manual Supplement. Psychological Assessment Resources, Odessa, FL.

Delsing, M.J.M.H., ter Bogt, T.F.M., Engels, R.C.M.E., Meeus, W.H.J., 2008. Adolescents' music preferences and personality characteristics. Eur. J. Personal. 22, 109–130.

Eysenck, H.J., 1967. The Biological Basis of Personality. Charles C. Thomas Pub Ltd, Springfield.

George, D., Stickle, K., Rachid, F., Wopnford, A., 2007. The association between types of music enjoyed and cognitive, behavioral, and personality factors of those who listen. Psychomusicology 19, 32–56.

von Georgi, R. (Ed.). (2013). Anwendung von Musik im Alltag: Theorie und Validierungsstudien zum IAAM [Use of Music in Everyday Life: Theory and Validation Studies With the IAAM]. Marburg: Tectum-Verlag.

Gerra, G., Zaimovic, A., Franchini, D., Palladino, M., Giucastro, G., Reali, N., 1998. Neuroendocrine responses of healthy volunteers to 'techno-music': relationships with personality traits and emotional state. Int. J. Psychophysiol. 28, 99–111.

Kunkel, M., Pramstaller, C., Bücher, S., von Georgi, R., 2008. A Construct-psychological Approach to the Measurement of Chill-sensations. vol. 7 Samples. http://www.gfpm-samples.de/.

Laeng, B., Eidet, L.M., Sulutvedt, U., Panksepp, J., 2016. Music chills: the eye pupil as a mirror to music's soul. Conscious. Cogn. 44, 161–178. https://doi.org/10.1016/j.concog.2016.07.009.

Montag, C., Reuter, M., Axmacher, N., 2011. How one's favorite song activates the reward circuitry of the brain: personality matters!. Behav. Brain Res. 225, 511–514.

Park, M., Henning-Fast, C., Bao, Y., Carl, P., Pöppel, E., Welker, L., 2013. Personality traits modulate neural responses to emotions expressed in music. Brain Res. 1523, 68–76.

Reinhardt, J., 2011. Die Modifikation von Musikpräferenzen unter Alkoholeinfluss. Eine psychophysiologische Studie (The modification of musical preferences under the influence of alcohol. A psychophysiological study). Technische Universität Dortmund, Dortmund.

Rentfrow, P.J., Gosling, S.D., 2003. The Do Re Mi's of everyday life: the structure and personality correlates of musical preferences. J. Pers. Soc. Psychol. 84, 1236–1256.

Salimpoor, V.N., Benovoy, M., Longo, G., Cooperstock, J.R., Zatorre, R.J., 2009. The rewarding aspects of music listening are related to degree of emotional arousal. PLoS

One 4, e7487. https://doi.org/10.1371/journal.pone.0007487.
Salimpoor, V.N., Benovoy, M., Larcher, K., Dagher, A., Zatorre, R.J., 2011. Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. Nat. Neurosci. 14, 257–262. https://doi.org/10.1038/nn.2726.
Salimpoor, V.N., van den Bos, I., Kovacevic, N., McIntosh, A.R., Dagher, A., Zatorre, R.J., 2013. Interactions between the nucleus accumbens and auditory cortices predict music reward value. Science 340, 216–219. https://doi.org/10.1126/science.1231059.
Sayette, M.A., 2017. The effects of alcohol on emotion in social drinkers. Behav. Res. Ther. 88, 76–89. https://doi.org/10.1016/j.brat.2016.06.005.
Tsai, C.-G., Chen, R.-S., Tsai, T.-S., 2014. The arousing and carthatic effects of popular heartbreak songs as revealed in the physiological responses of listeners. Music. Sci. 18, 410–422. https://doi.org/10.1177/1029864914542671.
Urban, N.B., Kegeles, L.S., Slifstein, M., Xu, X., Martinez, D., Sakr, E., 2010. Sex differences in striatal dopamine release in young adults after oral alcohol challenge: a positron emission tomography imaging study with [^{11}C]raclopride. Biol. Psychiatry 68, 689–696. https://doi.org/10.1016/j.biopsych.2010.06.005.
von Georgi, R., Grant, P., von Georgi, S., Gebhard, S., 2006. Personality, Emotion and the Use of Music in Everyday Life: Measurement, Theory, and Neurophysiological Aspects of a Missing Link. Der Andere Verlag, Tönning, Lübeck, Marburg.
Yoder, K.K., Albrecht, D.S., Dzemidzic, M., Normandin, M.D., Federici, L.M., Graves, T., 2016. Differences in IV alcohol-induced dopamine release in the ventral striatum of social drinkers and nontreatment-seeking alcoholics. Drug Alcohol Depend. 160, 163–169. https://doi.org/10.1016/j.drugalcdep.2016.01.001.