The Effects of Music Emotional Valence on Texas Holdem Gameplay Risk-Taking and EEG Mental State Amid Musical Background, Gender, and Skill Level

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Abstract

This study tested the effects of music emotional valence during *Texas Holdem* poker gameplay among musical background, gender, and skill level via self-report music evaluations, gameplay risk-taking, and electroencephalographic (EEG) mental state using the NeuroSky MindWave Mobile. 40 participants within their respective demographic groups played individually against a fixated dealer across three counterbalanced music interventions: no-music (NM), low-arousal positive (LAP) and negative (LAN). Musically-untrained (MU) subjects mainly yielded greater EEG attention and meditation levels (Att/Med) during the music interventions as compared to musically-trained (MT) subjects. Females self-reported higher emotional engagements towards the music and gained higher Att/Med in the presence of music, whereas males exhibited greater reactivity to the opposing music valences. Advanced players gained the greatest attention levels without music, but were lowered during both music interventions. While MU subjects, females, and novice players may have enhanced gameplay qualities in optimally lowly-arousing music interventions, MT subjects, males, and advanced players were suggested to fare better without background music. Subsequent research may explicate on the consistent correlations among music likeability, increased time and extents of bet placements, and suppressed Att/Med during LAN potentially caused by cognitive distractions, furthermore whether or not the presence of cathartic effects could significantly moderate this relationship.

Keywords: Music Valence, Poker Gameplay, Musical Background, Gender, Skill Level.

Introduction

Risk-taking is a form of decision-making involving consequential uncertainties (Damodaran, 2008); whereas "gambling" was defined as an act of wagering financial stakes on uncertain outcomes with hopes of desired profitable returns (Volberg et al., 2015). The line of study on gambling behaviours was initiated mainly on its association with excitement levels, whereby heart rate was significantly heightened during gambling activities (Coulombe et al., 1992; Coventry & Constable, 1999; Coventry & Hudson, 2001; Krueger et al., 2005). Wulfert et al. (2005) which examined the effects of winning expectations and affective excitement deduced gambling to be correlated with physiological arousal, particularly among winning players.

Background music has been a studied factor in risk-taking and gambling environments. In general, the effects of music tempo on risk extents was disputed between Enström and Schmaltz (2017) and Israel et al. (2019) which reported contradicting results. This dispute was similar for music preference on risk extents as well, between preferred (Halko et al., 2015) and disliked (Fujikawa & Kobayashi, 2012) music. Griffiths and Dunbar (1997) found that the absence of music in said environments could avoid unwanted interferences which eclipses other essential gambling aspects; however, there could potentially be an increase in negative tendencies (i.e. emphasis on losses) and limitations on excitement levels. As psychophysiological arousal was highly associated with gambling behaviours, bet speeds were similarly increased during faster-tempo background music conditions (Dixon et al., 2007; Spenwyn et al., 2010); while Brooks and Schweitzer (2011) subsequently discovered anxious music to accelerate response speeds. However, this was contradicted by Bramley et al. (2016a) whereby music tempo did not affect bet speed. Apart from bet speed, betting amounts were increased during slower-tempo music (Mentzoni et al., 2014), while risks may be increased during over-excitement and psychological comfortability states (Ho & Loo, 2022). Music preference was also a significant predictor in gambling which differs among demographics, most prominently among age group of gamblers or among those present within the vicinity (Griffiths & Parke, 2005; Mu et al., 2022).

Reviews on the Effects of Music Emotional Valence

"Emotion" was defined as a psychophysiological "self-feeling" (Denzin, 1984) based on a subjective experience stimulated by one's perception or reaction of the situation (MacCurdy, 1925; Frijda, 1986); whereas "valence" is a "central affective component" within the arousal states of individuals (Carruthers, 2018). Thus, "emotional valence" of musical contexts refers to the evoked emotions of a music which affects felt emotions of listeners, generally contrasted between "positive" and "negative" effects by previous studies (Cassidy & MacDonald, 2007; Nguyen & Grahn, 2017). "Positive-valence music" classifies music which evokes positive feelings of happiness, joy, contentment, etc.; while "negative-valence music" classifies music which evokes feelings of anger, sadness, depression, etc. (Fredrickson, 2001; Koelsch, 2018). This classification aligned with the contrasting valence quadrants of the Dynamics of Energy Model by Loehr and Schwartz (2003). Furthermore, arousal level of the contrasting emotional valences could be distinguished between "high" and "low" arousals in the pertaining model, in which its suitability as background music stimuli during varying task performances corresponds to one's optimal arousal threshold based on Hebb's (1955) optimal arousal law.

With this, while optimally low-arousal music was found to be more suitable for cognitively-involved tasks (Hallan & Price, 1998; Hallam et al., 2002; Bugter & Carden, 2012; Nguyen & Grahn, 2017; Niu et al., 2020) mainly due to its beneficial mood-calming effects (Jiang et al., 2016; Mu et al., 2022), the effects of contrasting music valence on task performances remains inconclusive (Straehley & Loebach, 2014; Landay & Harms, 2019), albeit felt emotions would significantly affect listeners' arousal levels as well (Smith & Morris, 1977; Lundqvist et al., 2009; Warmbrodt et al., 2022) or vice versa (Schachter & Singer, 1962). Studies on background music effects on poker or equivalent gambling games generally emphasized on tempo-arousal and genre-familiarity aspects of music (Griffths & Parke, 2005; Dixon et al., 2007; Spenwyn et al., 2010; Mentzoni et al., 2014; Bramley et al., 2016a), which lacked scrutinizations on music emotional valences instead.

Employment of EEG Instrument

In view of the extensive emphasis of neuroscientific studies within music psychophysiology research (Thaut & Hodges, 2018), the current study employed electroencephalographical (EEG) measures in monitoring brainwave activity. Previous studies which employed EEG approaches have reported significant associations of arousal with music favourability (Hadjidimitriou & Hadjileontiadis, 2012), emotional distinguishment (Ramirez et al., 2018), and pleasurability (Gao et al., 2020). Henceforth, the current study utilised the NeuroSky MindWave Mobile EEG instrument to determine subjects' mental state during the poker gameplay sessions, of which its patented attention and meditation (Att/Med) parameters were correlated with optimal arousal. Past studies have reported significant data reliability with high accuracy using the MindWave (Ghorpade et al., 2015; Rogers et al., 2016; Abo-Zahhad et al., 2018; Anil et al., 2018; Goode & Iwasa-Madge, 2019), mainly pertaining studies which involved manipulations of background music (Bhatti et al., 2016; Teixeira et al., 2018). Nonetheless, this was also the EEG instrument which was most available to us within the region.

Musical Background, Gender, and Skill Level

Being a part of a larger research, this study encompasses three demographic subject groups: musical background, gender, and poker-playing skill levels. Studies have reported contrasting brainwave activity among musicians and non-musicians through EEG (Fachner & Stegemann, 2013) with greater neural activation among musicians (Zuk et al., 2014). Moreover, musicians may potentially place greater cognitive attentiveness towards the background music which may disrupt their task performance and concentration (North & Hargreaves, 1999; Yang et al., 2016). Despite inconclusive and disputed evidences regarding the effects of music towards emotional responses and induction among musical background (Kreutz et al., 2008; Bigand et al., 2010), musical background may perhaps be potential moderating factor in impacting decision-making qualities (Smayda et al., 2018; Buelow et al., 2022). In terms of gender, Palomäki et al. (2016) deduced gender as a significant moderator in poker gameplay, suggesting males to possess greater social-inclination skills hence poker being a "male-dominated" game. Karageorghis et al. (2021) found females to yield greater heart rates when exposed to lyrical music interventions during cognitive-motor tasks, hinting females to potentially possess lower arousal tolerance than males. In terms of skill level, previous studies discovered higher-level players to possess greater cognitive capacities and gameplay capabilities, particularly on the social-inclination aspect of poker gameplay (Daly & Wiemann, 1994; Caso et al., 2005) whereby experienced players potentially make wiser betting decisions than the inexperienced (Laaksuo et al., 2015). This was elaborated by Bramley et al. (2016b) whereby "hardened gamblers" whom positioned their full concentration towards the gameplay task were least affected by the background music interventions.

The Current Study

Studies have reported that females are mainly more sensitive in emotional perception than males (Chen et al., 2018; Fischer et al., 2018; Abbruzzese et al., 2019), listeners with musical background being more sensitive to musical emotional valences than those without (Liu et al., 2018), while experienced players are mainly more emotionally-stable than the inexperienced during pressurizing situations in poker gameplay (Laaksuo et al., 2014). However, these studies placed emphases on perceptions of emotional cues rather than the effects of pertaining stimuli towards cognitive-motor task performances while Laaksuo et al. (2015) employed high-arousal negative and neutral stimuli interventions in poker gameplay; hence the novelty of the current study being to bridge the gap of limited associations among the effects of contrasting emotional valences of low-arousal music interventions deemed suitable for cognitive task performances based on its perceptions and effects of temporal mental states, and how it influences risk-taking behaviours during poker gameplay among musical background, gender, and poker-playing skill level. These three attribute variables were selected for the current study as musical background is a potential factor for perceptions of music stimuli, gender is a potential factor for emotional perceptions, while skill level is a potential factor for poker-playing behaviours.

Thus, this study aimed to determine the effects of music valence on risk and EEG mental state among the three demographic attribute groups during *Texas Holdem* gameplay with respect to several inconclusive questions as listed below: -

(1) Given that musical background is a significant factor in the effects of music on decision-making (Smayda et al., 2018; Buelow et al., 2022),

does musical background affect felt emotions of background music, attentiveness, and risk behaviours during gambling?

(2) As Palomäki et al. (2016) suggested poker to be a "male-dominated" game, is this notion still applicable when both genders are exposed to background music of opposing valences?

(3) Is the conclusion regarding the effects of music on gambling among different skill levels by Bramley et al. (2016b) applicable between background music of opposing valences?

This study encompasses two low-arousal music of opposing valences (positive/negative) and three measures: self-report music evaluations (familiarity, emotional engagement, likeability); gameplay risk-taking (frequency and extents); and EEG attention and meditation (Att/Med) parameters of the NeuroSky MindWave Mobile EEG instrument. The null hypotheses are: -

H01: There will be no significant differences in the self-report music emotional engagement evaluations (a) among all groups and (b) between LAP and LAN.

H02: There will be no significant differences in the self-report music likeability evaluations (a) among all groups and (b) across interventions.

H03: There will be no significant differences in gameplay risk frequency (a) among all groups and (b) across interventions.

H04: There will be no significant differences in gameplay risk extent (a) among all groups and (b) across interventions.

H05: There will be no significant differences in EEG attention levels (a) among all groups and (b) across interventions.

H06: There will be no significant differences in EEG meditation levels (a) among all groups and (b) across interventions.

Methodology

Subject Recruitment

The sample size was initially computed using G*Power. The input parameters were medium effect size (f = .25) and 5% error probability (α = .05, 1-β = .95) within 2-3 groups and three measurements representing number of interventions, which generated an a priori required sample size of 40 (1-β = .952). Thus, the current study sought 40 participants through criterion-i opportunistic snowball sampling within Klang Valley, Malaysia. Subjects were to be within ages 18-29, as this age group was associated with "higher gambling propensities" (Basham & White, 2002). Subjects were also required to possess compulsory basic knowledge on general poker gameplay with no problem gambling histories. This was filtered through the nine-item *Problem Gambling Severity Index* (PGSI) (Whelan et al., 2021, p.12) which assessed the extents of self-reported problem gambling. Being solely to ensure subjects did not experience any prior health- and financially-related gambling problems, all potential recruits had to label Items 8 (health implications) and 9 (financial implications) of the questionnaire as "0" ("Never") in order to participate. Potential subjects subsequently labelled themselves in one of the following demographic attribute categories: (a) musical background [musically-trained (MT) / musically-untrained (MU)]; (b) gender (male/female); and (c) poker-playing skill level (level-1: novice / level-2: intermediate / level-3: advanced). As the current study was part of a larger research, the sample size of each demographic group were not set to be equal.

Music Selection

The current study encompassed two music categories of contrasting emotional valences based on both the lower-arousal quadrants of the Dynamics of Energy Model by Loehr and Schwartz (2003): low-arousal positive (LAP) and negative (LAN). The LAP music playlist comprised of four jazz pieces by Café Music BGM Channel ("Happy Bossa", "Study & Study", "Study Bossa Nova", "Study Café"), whereas the LAN music playlist consisted of four piano solo pieces by Jurrivh ("Crying Alone", "Loneliness", "Pain", "Suicide Note"). All selected music pieces were in 4/4-time, with mean music tempi of LAP and LAN being 131.75 and 72.00 BPM respectively.

The LAP and LAN music classifications of the current study are in accordance with the descriptors by Ho and Loo (2023). The LAP music group was classified with "nonchalance", hence the term "nonchalant jazz" whereby jazz music could minimise sadness, enhance relaxation (Lynar et al., 2017) and brain functions (Geethanjali et al., 2012). The selected LAP pieces were acoustic guitar-piano duets without percussive instruments to maintain low-arousal atmosphere. Being "bossa nova" music, their tempi were slightly higher than most lighter jazz music to ensure adequacy of positive vibes. The LAN music group was classified with "despondency", which encompasses feelings of "lowly-spirited sadness and depression" (Williams, 2022, p.16). Tempi of the selected LAN music pieces were slower than the former group as mentioned. The acoustic piano timbre was reverbed with light strings sounds which potentially amplifies the negative effect trajectories.

As mentioned, both LAP and LAN playlists comprised of low-arousal instrumental music pieces which is deemed more suitable for cognitive-based tasks; and that lyrical music which is commonly listened among young adults (Mori & Iwanaga, 2014; Nunes et al., 2014) shall heighten listeners' cognitive load (Karageorghis et al., 2021; Warmbrodt et al., 2022) and would disrupt concentration (Perham & Currie, 2014), hence the recommendation of instrumental music (Herring & Scott, 2018; Chen, 2022) given poker gameplay being a task which involves cognitive decision-making (Palomäki et al., 2020). These music pieces were initially deemed as "potentially-unfamiliar"; however, familiarity was gauged as part of the self-report evaluations. The data were to be compared among the larger unfamiliar group should there be any participants whom reported familiarity to any of the selected music pieces.

Procedure

The experiment sessions were conducted among subjects individually based on their timing availability in a suitably-enclosed venue based on the "situational characteristics" mentioned in Valdez and Mehrabian (1994) and Spenwyn et al. (2010). The three music interventions were no-music (NM), LAP, and LAN. Being a within-subject study, NM was fixated as the initial intervention throughout to minimise warm-up effects, while the order of LAP and LAN were counterbalanced randomly. The music was played using Spotify Premium in shuffled sequence via stereo speakers at an adequately-equalized volume. Each gameplay session lasted 10 minutes. All participants wore the MindWave throughout the gameplay process. With a suggested data size of 400 (1-β = .9504) via G*Power, the closest EEG data interval was at every 10 seconds, which amounted to a total of 600 data readings in each gameplay session. The readings were obtained by pairing the MindWave with a master device via Bluetooth, of which were recorded through the *eegID* application and auto-tabulated in a common-separated values file.

The task of this study was to play *Texas Holdem* poker, conforming to its standard rules as stated in Sfetcu (2018). All players participated individually by playing one-on-one against the same dealer (26-year-old, MB, male, level-2) in a "heads-up" approach. To ensure equitable risk placement opportunities, bets and raises were only initiated by players, while the dealer was not allowed to fold (players had no knowledge on the latter). Only one ante was employed to minimise computational complexities. As this study did not involve real money, players and the dealer obtained $1,000 poker chips which were to be reset during each gameplay session. A minimum forced bet of $10 was enforced during each pre-flop bet stage. All card hands were not manipulated in order to garner results through a naturalistic poker gameplay setting.

Measures

The measures consisted of self-report music evaluations (familiarity, emotional engagement, likeability), gameplay risk-taking (frequency and extent), and EEG mental state (Att/Med).

The self-report music evaluations which comprised of three response items were vital to determine subjects' interactions with the music on top of the acquired measurements. The first dichotomous Yes/No item classified subject's familiarity with the music. The second emotional engagement (EE) item determined subjects' perceived interactions in tandem with the intended emotional trajectory classification of the music interventions in a Likert scale of 1 (lowest) to 5 (greatest effect). The third likeability (LIKE) item determined subjects' likings of the music in a Likert scale of 1 (most disliked) to 5 (most liked).

Gameplay risk-taking measures represented the speed and magnitude of bets placed in the poker gameplay task. "Risk frequency" represented bet speed per minute based on the quotient of total number of bets executed within the 10-minute gameplay timeframe which included all four betting stages in each round (pre-flop, flop, turn, river) and executed folds. "Risk extent" was calculated using an originally-formed "risk ratio (*R*)" based on the percentage of bet amount from the remaining amount on hand against one's card combination strength (*C*), which is a linear numerical representation of card hand strengths by dividing 1 amongst 104 possible combinations whereby a greater *C*-value indicates greater card hand power and vice versa. As a larger ratio indicates smaller risks and vice versa, risk ratio is inversely-correlated with risk extents.

$$\text{Risk Ratio } (R) = \frac{\text{Strength of Card Combination } (C)}{\text{Bet \% [Betting Amount / Remaining Amount (\$)]}}$$

$$R \text{ with \$1,000 loan} = \frac{\text{Strength of Card Combination } (C)}{\text{Bet \% [(Bet + \$1,000) / (Remaining + \$1,000)]}}$$

As poker is a game of chance with imperfect information (Palomäki et al., 2020), the risk ratio does not encompass winning probabilities and the opponents' card strengths. Risk extents were calculated for all four betting stages and any respective raises, but were disregarded for folds. If players have lost their full $1,000 before the time limit, the player was loaned with an additional $1,000, hence the latter *R* equation until the outstanding losses were regained.

EEG measures were employed in this study to empirically-determine subjects' mental state during poker gameplay in each music intervention. The measures were based on the attention and meditation (Att/Med) gauges using the NeuroSky MindWave Mobile EEG instrument. Both meters range from 1-100, of which correlate with attentiveness and mental calmness respectively, whereas lower values indicate cognitive and/or concentration disruptions (NeuroSky, 2017). This potentially aligns with Hebb's (1955) optimal arousal law whereby higher Att/Med values indicate closer proximity to being optimally-aroused.

Findings were analysed using (a) paired samples t-test for music emotional engagement and likeability ratings, (b) Welch's analysis of variance (ANOVA) for risk-taking and EEG measures, with (c) Spearman's rho (ρ) and Pearson's (r) correlation coefficients utilised for associations between measure types (ordinal and continuous) as categorized by Khamis (2008); whereby the significance threshold was fixated at $p < .05$. The analyses were followed by partial eta squared effect size (η^2; ≤ .01: small; .06: medium, ≥ .14: large) and statistical power measures (1-β; targeted at ≥ .80) which indicate magnitudes of differential data and probabilities in garnering significant results against false-negative hypothesis errors (Cohen, 1988; Descôteaux, 2007). Internal reliabilities of the self-report evaluation items were assessed using Cronbach's alpha (α), of which was targeted to be ≥ .70 to be "acceptably-reliable") and ≥ .80 to be considered as "highly-reliable" (Cronbach, 1951).

Findings

Among the 40 subjects, 8 were musically-trained (MT) while 32 were not (MU); 31 were males and 9 were females; 8 were level-1 players, 16 were level-2s, and 16 were level-3s. The mean age was 25.43 (SD = 2.218). Subjects' ethnicities were among local Malaysian Chinese and Indians. Only one level-3 male MT subject was familiar with Jurrivh. However, differences in all measures were insignificant between the one subject familiar to the LAN music and the larger unfamiliar group. Thus, music familiarity was disregarded in the subsequent analyses.

Music Evaluations

Overall internal reliability coefficients between self-reported music emotional engagement and likeability were α = .798 for LAP and -.609 for LAN. Through Welch's analysis of variance (Welch's ANOVA) significant differences in music emotional engagement evaluations were only yielded between gender for LAP [$F(1, 33.040) = 5.707$, $p = .023$, $\eta^2 = .061$, $1-\beta = .334$] and LAN [$F(1, 21.418) = 4.853$, $p = .039$, $\eta^2 = .071$, $1-\beta = .384$], albeit with moderate statistical power. Hence, females gave significantly higher emotional engagement evaluations towards LAP and LAN. There were no significant differences in music likeability throughout ($p > .05$).

Table 1
Data Analysis for the Self-Reported Music Evaluations Between LAP and LAN

	Music Emotional Engagement Evaluations Between LAP and LAN								
	M	*SD*	*SEM*	*t*	*df*	Sig.	*r*	η^2	1-β
MT	.500	1.309	.463	1.080	7	.316	.212	.063	.149
MU	.813	1.148	.203	4.003	31	< .001***	.232	.168	.936
Males	.806	1.276	.229	3.519	30	.001**	.179	.146	.884
Females	.556	.726	.242	2.294	8	.051	.177	.221	.517
Level-1	1.000	1.195	.423	2.366	7	.050*	.574	.148	.307
Level-2	.688	1.250	.313	2.200	15	.044*	.011	.138	.563
Level-3	.688	1.138	.285	2.416	15	.029*	.182	.178	.694
	Music Likeability Evaluations Between LAP and LAN								
	M	*SD*	*SEM*	*T*	*df*	Sig.	*r*	η^2	1-β
MT	2.875	1.356	.479	5.996	7	.001**	-.045	.728	> .999
MU	2.500	1.524	.269	9.280	31	< .001***	-.375*	.656	> .999
Males	2.452	1.567	.281	8.710	30	< .001***	-.305	.622	> .999
Females	3.000	1.118	.373	8.050	8	< .001***	-.289	.835	> .999
Level-1	2.500	1.512	.535	4.677	7	.002**	-.158	.641	.996
Level-2	2.625	.957	.239	10.967	15	< .001***	.182	.767	> .999
Level-3	2.563	1.931	.483	5.308	15	< .001***	-.659**	.608	> .999

*$p \leq .05$, **$p < .01$, ***$p < .001$.

Table 1 shows the data analysis for self-reported music evaluations between LAP and LAN via paired samples t-test. Differences in music emotional engagement were highly significant among MU subjects and males ($p \leq .001$, 1-β ≥ .884) and moderately significant within all skill levels ($p \leq .05$), but were insignificant among MT subjects and females. However, differences in music likeability were highly significant throughout ($p \leq .002$, $\eta^2 \geq .608$, 1-β ≥ .996). Paired samples correlation analysis indicated that correlations between the evaluations for LAP and LAN were only significant between MU subjects (r = -.375) and level-3s (-.659). All respond scores for both self-reported music evaluations towards LAP were higher than LAN throughout.

Risk and EEG Data

Through Welch's ANOVA, differences in risk frequency were only marginally-significant between musical background during LAP [F(1, 12.686) = 5.707, p = .023, η^2 = .061, 1-β = .334], and among skill levels during NM [F(2, 19.365) = 4.131, p = .032, η^2 = .188, 1-β = .711]. This demonstrated that MT subjects yielded slightly significantly-higher risk frequency than those without. Level-1 players yielded the greatest risk frequency during NM, followed by level-3s, and the lowest among level-2s. As for risk extents, differences were only significant between gender during NM [F(1, 350.808) = 19.848, p < .001, η^2 = .017, 1-β = .951]; and among skill levels during LAP [F(2, 469.687) = 6.772, p = .001, η^2 = .022, 1-β = .986] and LAN [F(1, 499.021) = 7.161, p = .001, η^2 = .010, 1-β

= .726]. Females yielded greater risk extents than males during NM. Level-3 players garnered the greatest risk extents during LAP, followed by level-1 players, and lowest among level-2 players.

Table 2

Data Analysis for Gameplay Risk Frequency and Extents Across Music Interventions

	Risk Frequency Across Music Interventions			
	Welch	Sig.	η^2	1-β
MT	$F(2, 11.023) = 13.921$	.001**	.523	.963
MU	$F(2, 59.896) = 14.083$	< .001***	.225	.997
Males	$F(2, 57.869) = 21.027$	< .001***	.313	> .999
Females	$F(2, 12.977) = .931$	.419	.071	.168
Level-1	$F(2, 10.084) = 5.209$	.028*	.345	.718
Level-2	$F(2, 27.659) = 13.640$	< .001***	.328	.981
Level-3	$F(2, 27.892) = 5.788$	.008**	.205	.817
	Risk Extent (*R*) Across Music Interventions			
	Welch	Sig.	η^2	1-β
MT	$F(2, 337.910) = .527$	.591	.002	.131
MU	$F(2, 1312.432) = 5.855$	.003**	.005	.849
Males	$F(2, 1297.352) = 4.360$	.013*	.004	.678
Females	$F(2, 353.295) = 1.706$	.183	.007	.386
Level-1	$F(2, 327.819) = 5.372$	.005**	.023	.869
Level-2	$F(2, 628.337) = 2.895$	.056	.006	.561
Level-3	$F(2, 681.549) = 1.763$	.172	.003	.352

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

Table 2 shows the data analysis of gameplay risk frequency and extents across interventions. Differences in risk frequency across music interventions were significant for all ($p \leq .028$, $.205 \leq \eta^2 \leq .523$, 1-β ≥ .718] except females. Risk frequencies were consistently highest during LAP and lowest during NM. Risk extents differences were only significant among MU subjects, males, and level-1 players across music interventions, whereby risk extents of MU subjects were highest during LAP and lowest during NM; while risk extents of males and level-1s were highest during LAN and lowest during NM.

Table 3 presents the data analysis for EEG Att/Med levels among groups through Welch's ANOVA. Differences in EEG attention levels between groups were significant for all groups ($p \leq .011$, $.003 \leq \eta^2 \leq .023$, 1-β ≤ .740) except between musical background during LAP. Meditation level differences were only significant between gender during LAP, but significant for all during LAN. Across music interventions, differences in Att/Med were highly-significant ($p < .001$, $.039 \leq \eta^2 \leq .366$, 1-β > .999) within all groups. Attention levels were consistently highest during LAP, lowest during NM overall, and lowest during LAN among MT subjects.

Meditation levels were greatest during LAN and lowest during NM consistently.

Table 3

Data Analysis for EEG Att/Med Readings Among Groups

	EEG Attention Level Among Groups			
	Welch	Sig.	η^2	1-β
Musical Background				
NM	$F(1, 777.765) = 20.709$	< .001***	.008	.992
LAP	$F(1, 680.652) = .291$	.590	.000	.090
LAN	$F(1, 758.258) = 57.534$	< .001***	.023	> .999
Gender				
NM	$F(1, 969.785) = 33.999$	< .001***	.012	> .999
LAP	$F(1, 958.159) = 34.729$	< .001***	.013	> .999
LAN	$F(1, 963.601) = 7.658$	.006**	.003	.740
Skill Level				
NM	$F(2, 1284.220) = 4.504$	.011*	.004	.775
LAP	$F(2, 1274.118) = 10.577$	< .001***	.009	.990
LAN	$F(2, 1429.143) = 13.299$	< .001***	.004	.843
	EEG Meditation Level Among Groups			
	Welch	Sig.	η^2	1-β
Musical Background				
NM	$F(1, 750.484) = .412$	.521	.000	.097
LAP	$F(1, 734.665) = .076$	.783	.000	.059
LAN	$F(1, 22.824) = 784.288$	< .001***	.009	.996
Gender				
NM	$F(1, 864.693) = 1.677$	.196	.001	.257
LAP	$F(1, 848.052) = 8.698$	.003**	.004	.854
LAN	$F(1, 911.808) = 36.045$	< .001***	.014	> .999
Skill Level				
NM	$F(2, 1295.388) = .969$	.380	.001	.217
LAP	$F(2, 1277.302) = 1.559$	.211	.001	.337
LAN	$F(2, 1429.143) = 13.299$	< .001***	.008	.981

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

Correlation Analyses

Table 4

Correlations of Music Evaluations and Risk Items

			MT	MU	Males	Females	Level-1	Level-2	Level-3
EE and Likeability	LAP	ρ	.756*	.634**	.772**	-.250	.661	.664**	.709**
	LAN	ρ	-.612	-.100	-.273	.182	-.737*	-.132	-.007
Risk Frequency									
E. Engagement	LAP	r	-.875**	-.015	-.311	.366	-.341	-.493	-.258
	LAN	r	.215	.111	.193	.232	-.399	.391	.102
Likeability	LAP	r	-.783*	.084	-.406**	-.037	-.046	-.497	-.568
	LAN	r	-.092	-.097	.140	.095	.495	-.345	.320
Risk Ratio *(R)*									
E. Engagement	LAP	r	.049	.466**	.155	.075	.420	.018	-.109
	LAN	r	.404	.198	.095	.013	.598	-.143	-.035
Likeability	LAP	r	-.067	.236	-.163	-.386	.185	-.161	-.289
	LAN	r	-.764*	-.150	-.379*	.031	-.714*	-.110	-.554*

*$p < .05$, **$p < .01$. Note: risk extent is inversely-correlated with risk ratio.

Table 5

Correlations of All Items with EEG Att/Med

Pearson Correlation (*r*)			MT	MU	Males	Females	Level-1	Level-2	Level-3
Inter-Correlation	NM		.267	-.333	-.294	.069	-.541	.385	-.696**
	LAP		-.435	-.372*	-.376*	-.267	-.553	-.383	-.285
	LAN		.828*	.655**	.660**	.823**	.591	.692**	.889**
E. Engagement	LAP	Att	.200	-.140	-.147	.125	.013	.159	-.440
		Med	.183	-.199	-.024	-.540	-.313	-.230	.106
	LAN	Att	.227	-.097	.066	-.627	-.079	-.059	-.017
		Med	.345	.062	.148	-.470	.448	.363	-.178
Likeability	LAP	Att	.469	-.453**	-.328	-.013	-.061	-.113	-.510*
		Med	-.049	.182	.189	.319	.140	.032	.293
	LAN	Att	-.924**	-.047	-.216	-.509	-.624	-.286	-.199
		Med	-.704	-.066	-.084	-.575	-.771*	-.379	-.011
Risk Frequency	NM	Att	.436	-.003	.059	.264	-.712*	.117	.454
		Med	.881**	-.126	-.076	.396	.555	.584*	-.233
	LAP	Att	-.049	.318	.277	.652	.492	-.371	.708**
		Med	-.410	.048	-.132	.051	.359	.167	-.253
	LAN	Att	.041	-.157	.006	-.130	-.298	.105	-.228
		Med	.263	-.046	.139	.000	-.800*	.422	-.035
Risk Ratio (*R*)	NM	Att	-.869**	-.249	-.216	.202	-.600	.155	-.266
		Med	-.170	.198	.162	-.011	-.019	.568*	.251
	LAP	Att	-.053	.321	.176	.091	.103	.329	.344
		Med	-.578	-.389*	-.437*	-.230	-.586	-.273	-.596*
	LAN	Att	.712*	.037	.190	.286	.510	.304	.231
		Med	.521	.218	.240	.321	.413	.497*	.266

*$p < .05$, **$p < .01$. Note: risk extent is inversely-correlated with risk ratio.

Table 4 presents the correlations of music evaluations and risk items. Through Spearman's rho (ρ) correlation analysis, overall inter-correlations between self-reported music emotional engagement and likeability evaluations were significantly correlated for LAP (ρ = .645), but not for LAN (-.226). Inter-correlations between both items for LAP were generally positive and strong among all groups except females and level-1s; whereas inter-correlations between both items for LAN were only significantly negatively-correlated among level-1s (-.737). Risk frequency was negatively-correlated with emotional engagement (-.875) and likeability (-.783) towards LAP music among MT subjects; whereas music likeability was negatively-correlated with risk frequency among males during LAP (-.406). The music emotional engagement ratings were negatively-correlated with risk extents among MU subjects during LAP (.466); whereas music likeability was negatively-correlated with risk extents among MT subjects, males, level-1 players, and level-3 players ($r \geq -.379$).

Table 5 presents the Pearson correlations of all items with Att/Med levels. Att/Med inter-correlations were consistently strong within all groups during LAN ($r \geq .660$) except among level-1s. There were no significant correlations between music emotional engagement ratings and Att/Med. Music likeability ratings were negatively-correlated with attention levels among MU subjects ($r = -.453$) and level-3s (-.510) during LAP, and among MT subjects (-.924) during LAN; whereas were negatively-correlated with meditation levels among level-1s (-.771) during LAN. Risk frequencies were negatively-correlated with attention levels among level-1s during NM (-.712) and positively among level-3s during LAP (.708); whereas were correlated with meditation levels during NM among MT subjects (.881) and level-2s (.584), however were negatively-correlated among level-1s during LAN (-.800). Risk extents were negatively-correlated with attention levels during NM (-.869); and strongly-correlated with meditation levels among level-2s during NM (.568) and LAN (.497), but negatively during LAP among MU subjects (-.389), males (-.437), and level-3 players (-.596).

Discussion

Self-Report Music Engagement and Likeability

H01(a) which stated that there would be no significant differences in the self-reported music emotional engagement evaluation responses among all groups could only be rejected between gender during LAP and LAN. H01(b) which stated that said differences would be insignificant between LAP and LAN was rejected for all except among MT subjects and females. H02(a) which stated that there would be no significant differences in the self-reported music likeability evaluation responses among all groups was accepted. However, H02(b) which stated that said differences would not be significant between LAP and LAN was fully rejected, as all response differences were highly significant within all groups throughout.

Gender was discovered to be the only significant predictor for music emotional engagement, as females provided significantly greater emotional engagement scores for both LAP and LAN music interventions than males, albeit yielding lower data power. However, the differences in music emotional engagement ratings of females were insignificant between LAP and LAN. This presented that females were more engaged with the emotional trajectories of the music interventions than males, whereas males were more affected by the varying emotional valence of the music than females. As for musical background, despite MT subjects providing greater (albeit insignificant) emotional engagement scores for both LAP and LAN than MU subjects, emotional engagement ratings between the contrasting music valences were only significantly differed among MU subjects. This suggests that MT subjects may be slightly more engaged to the emotional trajectories of music than MU subjects thus potentially being more inert to the contrasting music valences, while emotional engagement of MU subjects towards LAN music were significantly lowered compared to LAP. Thus, findings corroborated Bigand et al. (2010) whereby music emotional engagement were similarly unaffected between musical background, but differences only yielded significant contrasts within the musically-untrained subjects. This contradicts Liu et al. (2018) which reported greater emotional sensitivity among MT subjects.

As for music likeability, its differences were significant between LAP and LAN throughout, but were insignificant when compared among all groups. This evidently demonstrated whereby despite all three demographic groups were not significant predictors for music likeability, the likeability ratings of LAP music were unanimously greater than LAN. Emotional engagement and likeability responses towards LAP were significantly correlated throughout except among females and level-1 players ($r \geq .634$); however, both items towards LAN were only negatively-correlated among level-1s ($r = -.737$). Despite the insignificant findings among skill levels, this suggests that novice players may possess greater likelihoods in yielding lowered emotional engagements but may exhibit greater likings towards LAN music than the advanced players.

Poker Gameplay Risk Frequency and Extent

H03(a) which stated that there would be no significant differences in risk frequency among all groups was only rejected among musical background during LAP and among skill levels during NM. However, H03(b) which stated that said differences would not be significant across music interventions was fully rejected among all groups except females. H04(a) which stated that there would be no significant differences in risk extents among all groups could only be rejected between gender during NM, and among skill levels during LAP and LAN. H04(b) which stated that said differences would not be significant across music interventions was only rejected among MU subjects, males, and level-1 players.

Therefore, risk frequency was significantly higher among MT subjects during LAP than MU subjects, and were significantly higher among level-3 players compared to level-2s during NM. Instead, risk frequency differences across music interventions were significant for all groups except among females, whereby risk frequencies were highest during LAP, followed by LAN, and lowest during NM. However, correlational analyses indicated whereby greater emotional engagement and likeability evaluation ratings towards the LAP music among MT subjects were correlated with lower risk frequencies. This potentially indicated whereby LAP music was a significant moderator in risk frequency among musical background, but the bet speeds could potentially be decelerated as engagement and likeability ratings towards the music intervention increases. This was applied among males as well, whereby greater likeability towards LAP was significantly correlated with slowered bet speeds among males. Despite faster-tempo music evidently increasing bet speeds (Dixon et al., 2007; Spenwyn et al., 2010), the bet speeds may be slowered when players exhibit higher engagement and likeability towards the music.

As for risk extents, females took greater risk extents during NM, level-3 players took the greatest risk extents during LAP whereas level-1 players took the greatest risk extents during LAN, while risk extents of level-2s were significantly the lowest during LAP and LAN. Across music interventions, risk extents of males and level-1 players were highest during LAN, while risk extents of MU subjects were highest during LAP, whereas risk extents of these groups were lowest during NM throughout. Correlational analyses indicated that the greater emotional engagement ratings towards LAP music would potentially yield lower risk extents among MU subjects, albeit insignificant risk extent differences of MU subjects between LAP and LAN. Consistent correlations between risk extents and likeability of LAN music among MT subjects, males, level-1s, and level-3s indicated that risk extents would be greater as likeability towards LAN music increases. This partially corroborated Halko et al. (2015) which deduced risks to be heightened with liked music, however only applicable to LAN in the current study despite the greater likeability ratings towards LAP; including Smayda et al. (2018) and Buelow et al. (2022) which found musical background to affect decision-making, as the current study only found significant effects on risk extents in MU subjects. Additionally, correlational analyses of MU subjects which reported higher EEG attention being associated with lower meditation had greater likelihoods in yielding lower music likeability ratings and risk extents during LAP.

EEG Mental State Measures

H05(a) which stated that there would be no significant differences in EEG attention levels among all groups was rejected throughout except between musical background during NM. H06(a) which stated that there would be no significant differences in EEG meditation levels among all groups was only rejected between musical background during LAN, between gender during LAP and LAN, and among skill levels during LAN. However, H05(b) and H06(b) which stated that there would be no significant differences in Att/Med across music interventions were confidently rejected, as all Att/Med levels differences were significant within all groups throughout all music interventions.

EEG Att/Med were higher among MU subjects during NM and LAN than MT subjects. Attention levels of males were higher than females during NM, but vice versa during LAP and LAN. Meditation levels of males were higher than females during LAP, but vice versa during LAN. Attention levels of level-3s and -1s were highest and lowest respectively during NM, but attention levels of level-1s during LAP and both Att/Med during LAN were conversely highest. Attention levels of level-3s were significantly negatively-correlated with likeability ratings, and positively with both risk frequency and extents during LAP. Hence, this indicated whereby level-3 players may potentially perform better without music as compared to level-1s, as their greater likeability of LAP music was associated with faster bet speeds and greater risk extents. As for level-1 players, their meditation levels were negatively-correlated with likeability and risk frequency during LAN, indicating that their greatest meditation levels were associated with lower music likeability ratings and slower betting speeds.

Across music interventions, attention levels were highest during LAP throughout, followed by LAN, and lowest during NM within all groups except MB, whereby attention levels of MT subjects were lowest during LAN instead. This was indicated by the highly-significant negative correlations between attention levels and likeability ratings of LAN music among MT subjects. Nevertheless, with high data power, this clearly demonstrated whereby music valence was a significant predictor for attentiveness in general, whereby the LAP music intervention was suggested to be most suitable in enhancing attention levels during risk-taking. Unlike attention levels, meditation levels within all groups were greatest during LAN, followed by LAP, and lowest during NM. This suggests cathartic effects to be potentially present during LAN with respect to its significantly lower likeability against the highest meditation levels. Thus, feelings of despondency elicited by LAN may not have captured the greatest despondent engagements, but the despondent effects of the LAN music could have subconsciously triggered catharsis which potentially reversed the repressed negative effects and enhanced mental calmness.

Discussion within Attribute Groups

Among musical background, music emotional engagement was not significantly differed, whereas only MU subjects were significantly affected by the contrasting music valences, hence opposing Liu et al. (2018) which reported the opposite. Risk extents only exhibited marginal differences between musical background, while only MU subjects were significantly affected across music interventions. Att/Med of MU subjects were generally higher during NM and LAN. Higher likeability towards LAN was associated with greater risk extents and lower attention levels among MT subjects, and that increased emotional engagement and likeability ratings of LAP among MT subjects were associated with lower risk frequencies. This inherently suggests whereby MT subjects may have diverged more cognitive attention towards the music which potentially disrupted their gameplay behaviours, hence the higher music engagement ratings and its associations with slower bet speeds. This corroborated Fachner and Stegemann (2012) which yielded significant EEG data among musical background; however partly placed Zuk et al. (2014) in a rather vague position, as Att/Med levels of MU subjects were greater in the current study. In response to Kreutz et al. (2008) and Bigand et al. (2010), felt emotions and music engagement were unaffected between musical background, but only yielded significant contrasts within MU subjects. In response to Smayda et al. (2018) and Buelow et al. (2022), the current study discovered risk differences not being apparent between musical background, but suggests MU subjects to exhibit greater gameplay qualities in the presence of music whereas MT subjects may potentially perform better without music.

As for gender, females self-reported greater emotional engagement and likeability towards both music interventions which aligned with several past studies (Chen et al., 2018; Fischer et al., 2018; Abbruzzese et al., 2019), while only males reported significant differences for music emotional engagement between LAP and LAN. Despite females only yielding greater risks than males during NM, only risk extents of males were significantly differed across music interventions. Baseline attention levels of males were higher, while attention levels of females turned higher during LAP and LAN. Hence, this suggests that females were more cognitively engaged to the music, whereas males were more reactive to the contrasting music valences. As heart rate measurements were not part of the current study, given the notion by Palomäki et al. (2016) whereby poker is a “male-dominated” game and the conclusions of Karageorghis et al. (2021) whereby females yielded greater heart rates (hence greater arousal levels) than males during exposure, this theorises that the higher risk extents of females during NM and their increased attention levels during LAP and LAN could be associated with greater arousal and potential cognitive placement priority towards the music than the gameplay task, hence the insignificant differences in emotional engagement ratings and risk measures across the music interventions. Music likeability could be a significant predictor within risk-taking across music valences for males, as lowered bet speeds were correlated with greater likeability of LAP, while greater likeability of LAN was correlated with greater risk extents and EEG meditation levels.

Among skill levels, level-3 players naturally exhibited the highest attention levels during NM, while level-1s yielded greater attention in the presence of music. In response to Bramley et al. (2016b), the current study suggests likeability of the contrasting music valences to be a significant predictor within risk-taking behaviours among varying poker-playing skill levels, as level-3 players may have executed risks rather hastily during liked music given their greatest risk frequency and extents during LAP, whereas said theory could inherently be applicable for meditation levels among level-1s as well based on correlations between faster bet speeds and lowest likeability ratings during LAN. Therefore, the current study suggests novice players to perform better with music, whereas advanced players could perform better without music due to their greater reactivity towards music likeability and opposing background music valences. While Laaksuo et al. (2014) discovered higher-levelled players to be more emotionally stable, the current study suggests higher-levelled players to be easily distracted by the affective valence or even the presence of background music during poker gameplay.

Limitations

The current study only actively manipulated emotional valence of low-arousal music, hence arousal and heart rate measures were unaccounted. As this study only involved subjects of ages 18-29, replications with elder participants may be conducted based on their preferential music genres as suggested by Griffiths and Parke (2005) and Mu et al. (2022). Similar to Spenwyn et al. (2010) and Bramley et al. (2016), real money was not involved in the current study as this would burden subjects financially, of which may potentially influence subjects to play the game rather unrealistically which unrepresented real-world gambling situations. However, the usage of real money would definitely produce different sets of results, partly due to potential arousal and excitement escalations when real monetary stakes are dealt. Despite the intended emotional trajectories of music interventions, subjects' temporal mood prior to experimental participation could not be fully controlled, of which could have influenced the music emotional engagement evaluations and Att/Med data. As participants were recruited using non-probability sampling, personality trait (extroversion and neuroticism) and social-inclination capabilities could not be ruled out as potential predictors in influencing the gameplay atmosphere and yielded results. As the dealer was not allowed to fold, it is not beyond the bounds of possibility that after several rounds, advanced players may notice and somehow take advantage of this. However, this does not outweigh the potential selection bias on risk data should the dealer be able to fold against players' bets. It is important to note whereby differences in number of subjects with musical background and females were much lesser than their respective counterparts, findings may not be fully validatable unless replicated in equal sample sizes.

Conclusion

Through addressing the gap of limited research on the effects of contrasting music valences on poker gameplay behaviours among musical background, gender, and skill level, the current study proposes the presence of lowly-arousing music to be most optimal for novice and MU players during poker gameplay, whereas advanced and MT players shall potentially fare better without any music interventions. Females inherently exhibit greater engagements towards the background music, whereas males showed greater tendencies to be more reactive to varying music valences. While the current findings contributed in distinguishing music perceptions and its effects on poker gameplay among the pertaining attributes, this paved a way for subsequent research to explicate and determine the most optimal background music for each demographic group during poker gameplay or in equivalent risky gambling and decision-making situations.

Future research may explicate on how music likeability resulted in slower betting speed but increased risk extents which were possibly due to mental and cognitive distractions as indicated by its negative correlations with Att/Med, and whether or not music emotional engagement is a moderator within this relationship given its significant correlations with likeability. Despite without any significant differences in all measures, replications may be executed with music familiarity as this variable was disregarded due to its minimal differential sample size. In view of studies reporting cathartic music to mitigate negative emotions (Sachs et al., 2015; Yoon et al., 2020), the presence of catharsis could be further scrutinised therapeutically based on its possible effects during LAN, including its effects on poker gambling behaviours.

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Declaration of Competing Interests

The authors declare that there are no competing interests.

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Ethical Research Declaration

Ethical clearance of this research was approved by the University of Malaya Research Ethics Committee (UMREC) (UM. TNC2/UMREC_1143).

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