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Investigating the influence of music tempo on arousal and behaviour in laboratory virtual roulette

Abstract

A number of studies indicate that fast music influences performance in everyday activities including shopping and gambling, but the mechanisms through which this effect is realised are not well understood. This study investigates whether fast tempo music influences gambling via an effect on arousal using a laboratory virtual roulette task. One hundred and forty-four participants played virtual roulette whilst listening to fast tempo, slow tempo or no music. Music tempo alone did not influence betting speed, expenditure or risk-taking. Furthermore tempo did not influence participants' physiological or subjective arousal levels, nor participants' opinions of the musical stimuli in terms of liking, familiarity, fit or its ability to aid concentration. Our findings suggest that there are some circumstances under which the effect of music tempo does not operate and therefore provides an insight into the limits of music tempo as an explanation for music effects on behaviour. This study has implications for the way that musical characteristics are operationalised in future research into music's effects on behaviour.

Keywords

Tempo, background music, arousal, gambling, behaviour

Music tempo influences a range of behaviours within retail and commercial environments (see North & Hargreaves, 2008 for a review). Research suggests that fast tempo music increases the speed at which individuals eat (Roballey et al., 1985), drink (McElrea & Standing, 1992), move through a supermarket (Milliman, 1982), drive (Brodsky, 2002) and read (Kallinen, 2002). Fast tempo music can also increase risk-taking in a simulated driving context (Brodsky, 2002). Slow tempo music can reduce expenditure in supermarket (Milliman, 1982) and restaurant (Caldwell & Hibbert, 2002) settings. The effects of music, as observed in other retail, commercial and laboratory environments, may transfer to certain gambling behaviours. Gambling is a suitable paradigm in which to explore music's effects on behaviour because it requires individuals to use a range of psychological processes including attention, judgement, decision-making and memory. Background music often features within the design of gambling activities (Bramley & Gainsbury, 2015) and environments (Griffiths & Parke, 2005), where it is used to promote and enhance the gambling experience (Parke & Griffiths, 2007). Music in gambling contexts can be considered as a structural characteristic, i.e., a feature that can initiate or maintain gambling participation (Parke & Griffiths, 2006).

During gambling, individuals perform speed-related and monetary behaviours. A number of studies have found that music can influence indices of gambling behaviour (Bramley, Dibben, & Rowe, 2014; Dixon, Trigg, & Griffiths, 2007; Mentzoni, Laberg, Brunborg, Molde, & Pallesen, 2014; Noseworthy & Finlay, 2009; Spenwyn, Barrett, & Griffiths, 2010). Noseworthy and Finlay (2009) found that fast tempo music led slot machine players to underestimate the time they had spent gambling. Betting speed, risk taking and expenditure are considered behavioural measures of gambling intensity. Mentzoni et al. (2014) found that slow tempo music led participants to place more bets and fast tempo music led to quicker reaction times during a simulated card game. Three studies have found that fast tempo music leads to quicker betting in laboratory virtual roulette (Bramley et al., 2014; Dixon et al., 2007; Spenwyn et al., 2010). There is a lack of direct evidence for effects of music on expenditure and risk taking in gambling contexts, which suggests that tempo does not exert an influence on those behaviours. But the weight of evidence suggests that tempo can influence speed-related behaviours (e.g., betting speed, reaction time and number of bets placed) and time estimations, across a range of gambling activities (i.e., virtual roulette, a simulated card game and slot machines).

However, the claim that background music's effects on speed-related gambling behaviours can be attributed to tempo is open to challenge. Studies that have investigated the influence of tempo on laboratory gambling behaviour employed different pieces of music for each condition; consequently music genre as well as other characteristics are confounded with music tempo (Dixon et al., 2007; Mentzoni et al., 2014; Spenwyn et al., 2010). For example, Mentzoni et al. (2014: 104) used a "slow paced jazz music soundtrack" and a "fast paced popular melody". Dance music was utilised within two studies (Dixon et al., 2007: Spenwyn et al., 2010); "upbeat" dance music for the fast tempo condition and "chill-out" dance music for the slow tempo music condition (Spenwyn et al., 2010). Unfortunately, neither Spenwyn et al. (2010) nor Dixon et al. (2007) identified the stimuli used in their studies, therefore it is not possible to analyse whether the musical stimuli differed in other ways than tempo, but it is highly likely that they did.

This inconsistent operationalisation of tempo is not confined to those investigating gambling behaviour. For example, within a meta-analysis investigating the impact of background music on adult listeners, out of 16 studies which Kämpfe, Sedlmeier, and Renkewitz (2011) identified as having systematically manipulated the tempo of background music, two omitted precise details of stimuli including the beats per minute (bpm) utilised for the fast and slow conditions (Balch, Bowman, & Mohler, 1992; El Sayed, Farrag, & Belk, 2003) and only six utilised musical stimuli which manipulated music tempo alone (McElrea & Standing, 1992; Herrington & Capella, 1996; Kallinen, 2002; Oakes, 2003; Oakes & North, 2006; Waterhouse, Hudson, & Edwards, 2010). Therefore musical stimuli that varied in musical parameters like genre, mode and timbre may have exerted independent effects on behaviour.

Current understanding of tempo's influence on behaviour is largely based upon empirical studies in which the authors did not solely manipulate tempo, exert strict control over the musical stimuli or provide comprehensive details of the stimuli employed. Two studies which have manipulated tempo while controlling for other musical parameters suggest that fast tempo music increases drinking (McElrea & Standing, 1992) and cycling speeds (Waterhouse et al., 2010). Thus there appears to be a lack of systematic evidence regarding which behaviours are influenced by tempo alone.

A number of different psychological mechanisms have been suggested to explain the proposed effects of tempo on behaviour. In the case of gambling, the behavioural effect of music tempo may be mediated by the influence of music on attention (Noseworthy & Finlay, 2009), fit (Spenwyn et al., 2010), and/or arousal (Bramley et al., 2014; Dixon et al., 2007). Fast tempo music may distract participants from the gambling task and impair their performance (Bramley et al., 2014; Noseworthy & Finlay, 2009). The concept of musical "fit" could also explain music's influences on behaviour as demonstrated by Spenwyn et al. (2010), who found that fast tempo music combined with red lighting led to quicker betting during laboratory virtual roulette. Fast tempo music and red lighting may have matched individuals' expectations of (i.e., fitted with) a gambling environment (Spenwyn et al., 2010).

The most commonly accepted explanation as to why music tempo effects aspects of laboratory virtual roulette gambling behaviour is that music induces changes in arousal which impacts on the speed of motor behaviour (Bramley et al., 2014; Dixon et al., 2007; Spenwyn et al., 2010). This is despite there being limited evidence available to support or refute this explanation. Arousal is the state of physiological and psychological readiness for action (Thayer, 1989), and commonly gauged in empirical research using subjective self-report and physiological measurement. In theory, fast tempo music has more arousal potential than slower music because more events are occurring within the same time span creating increased stimulation and making more processing demands (Berlyne, 1971). This explanation was put forward within two studies that have found that fast tempo quickened betting speed in laboratory virtual roulette (Dixon et al., 2007; Spenwyn et al., 2010). However, Bramley et al. (2014) tested this explanation and found that subjective arousal did not mediate music's effects on laboratory virtual roulette gambling behaviour. This suggests that music tempo might not induce changes in subjective arousal and impact upon betting speed in a laboratory gambling situation although it is currently unknown whether tempo-induced physiological arousal occurs.

Evidence to support the assertion by Berlyne (1971) that fast tempo music increases individuals' physiological arousal is found within music and emotion studies. Fast tempo music can increase listeners' heart rate (HR, Bernaldi, Porta & Sleight, 2006; Coutinho & Cangelosi, 2009; Gomez & Danuser, 2007) and skin conductance level (SCL, Carpentier & Potter, 2007; Coutinho & Cangelosi, 2009; Gomez & Danuser, 2007). Furthermore, research conducted within the field of exercise studies suggests that tempo can influence physiological arousal when performing a concurrent task. Fast tempo music increased HR and led to higher treadmill speeds (Edworthy & Waring, 2006). Similarly, when cycling, fast tempo music increased participants' HR, and they cycled farther and faster (Waterhouse et al., 2010). However, tempo can influence behaviour without influencing physiological arousal. Brodsky (2002, experiment 1) found fast tempo music did not influence HR or heart rate fluctuation (HRF, degree of fluctuation in beat-to-beat heart rate), but did lead to poorer vehicle control during simulated driving. HR and SCL are the most common measures used to detect physiological responses to music (see Hodges, 2009 for a review), but music tempo might affect other measures of physiological arousal. For example, Brodsky (2002, experiment 2) found that fast tempo music did not affect HR, but HRF decreased and participants committed more traffic violations and drove at a faster speed. Consequently, it appears that the links between tempo, arousal and behaviour are not straightforward.

Listeners' subjective arousal can also be increased by fast tempo music (Balch & Lewis, 1996; Husain, Thompson, & Schellenberg, 2002). Coutinho and Cangelosi (2011) found that loud, fast, higher pitch and sharper sounds correlated with increased subjective arousal. Therefore, it appears that a relationship exists between listening to fast tempo music and listeners perceiving higher levels of activation. Research has also indicated that relationships might exist between subjective and physiological arousal. Van der Zwaag, Westerink, and van den Broek (2011) found a positive correlation between subjective arousal and skin conductance responses and a negative correlation between heart rate variability and subjective arousal during an office task performed whilst listening to background music. Coutinho and Cangelosi (2011) found a positive correlation between HR and subjective arousal during a music listening task, although SCL and subjective arousal did not correlate.

Studies that investigate music's effects on gambling also need to consider that gambling participation can also influence physiological and subjective arousal. Heart rate (Coulombe, Ladouceur, Desharnais, & Jobin, 1992; Coventry & Hudson, 2001; Diskin, Hodgins, & Skitch, 2003; Leary & Dickinson, 1985) and skin conductance level (Diskin et al., 2003) can increase during periods of gambling. Changes in subjective arousal have also been recorded in gambling situations (Diskin & Hodgins, 2003; Leary & Dickinson, 1985). Subjective tension can also be implicated in gambling participation – some individuals gamble in order to reduce tension (Wardle et al., 2011), recalling and experiencing losses during a gambling session can increase tension for some gamblers (Sharpe, 2004), and individuals may experience increased tension prior to gambling (Padhi, Mehdi, Craig, & Fineberg, 2012).

This discussion of the relationships between tempo and behaviour reveals two main gaps in current understanding. First, there is limited evidence that music tempo may be able to influence gambling, but the extent to which it is able to do so once other musical parameters are controlled for remains open. Second, the idea that arousal is the psychological mechanism underlying music tempo's effects on betting speed in laboratory virtual roulette (e.g., Dixon et al., 2007; Spenwyn et al., 2010) has yet to be confirmed empirically. This research first examines the links between tempo and arousal by conducting a pre-study which tests whether musical stimuli that differ solely by tempo influence arousal. Following this, the main study examines the relationship between tempo, arousal and behaviour by investigating whether music tempo alone influences laboratory virtual roulette gambling behaviour via its effect on physiological and subjective arousal. Based on prior research indicating effects of tempo on behaviour even where other parameters were controlled, we expect the faster tempo music to elicit faster betting speed, and increase subjective and physiological arousal.

Method: Pre-study music selection

Participants

Fifteen volunteers (5 male; M age = 35.7 years) comprising staff and students from The University of Sheffield completed the pre-study. Participants were recruited for the pre-study by email.

Materials

Musical Stimuli. The musical stimuli were composed specifically for this study by the first author and a music technologist who composes electronic music. Two versions of a musical composition were produced, a fast tempo version (120 bpm) and a slow tempo version (72 bpm), following the classification employed by Milliman (1982) and others (Bramley et al., 2014; Caldwell & Hibbert, 1999; Dixon et al., 2007; Spenwyn et al., 2010). The stimuli were instrumental, featured synthesised instruments, were in the key of D major and composed in 4/4 meter. The fast tempo stimulus utilised short repetitive phrases, had a strong beat, little dynamic variation and could be described as “activating”

(Leman et al., 2013) or “motivating” music (Franěk, van Noorden, & Režný, 2014). The fast tempo version was slowed using a time-stretching algorithm within the software program Sound Forge to create the slow tempo stimulus. Excerpts from the musical stimuli are available at https://soundcloud.com/stephanie-bramley/sets/pre-test-musical-stimuli.

Measures

Subjective valence, arousal and tension. Subjective arousal can correlate with physiological arousal (Coutinho & Cangelosi, 2011; Van der Zwaag et al., 2011). To measure subjective arousal, tension and valence, a three-dimensional model of affect was employed (Schimmack & Grob, 2000). Participants rated how they felt “right now” along three dimensions (unpleasant-pleasant; bored-energetic; calm-tense), from “extremely” to “not at all”. Responses to each dimension were scored from one to nine and used for analysis (1 = “extremely” unpleasant, bored or calm; 9 = “extremely” pleasant, energetic or tense).

Procedure

The pre-study was administered online; participants first gave their informed consent before providing demographic data (i.e., age and gender). Next, baseline measures of subjective valence, arousal and tension levels were recorded. Following this, participants were instructed to listen to a 30-second excerpt of the fast and slow musical stimuli at a comfortable volume. Order of stimulus presentation was randomised. After listening to each excerpt, participants completed a post-task measure of subjective valence, arousal and tension.

Results

Paired t-tests revealed no significant differences between participants' subjective valence t(14) = 1, $p > .05$ or tension ratings t(14) = -.56, $p > .05$ after listening to the fast or slow tempo musical excerpts. Participants' level of subjective arousal was significantly higher following the fast tempo music (M = 5.67, SD = 1.35) compared to the slow tempo music (M = 5.20, SD = 1.61), t(14) = 2.17, $p < .05$, r = 0.15. The results supported the suggestion from Berlyne (1971) that fast tempo causes more arousal in listeners, although the effect size was small (Cohen's d = 0.32). These musical stimuli were used in the main study to enable comparisons between the results of other studies which have employed similar tempo differences (e.g., Bramley et al., 2014) and to examine whether music tempo alone influences gambling behaviour.

Method: Main Study

Design

A one-way, between-participants design was employed and participants were randomly assigned to no music, slow tempo or fast tempo music conditions. Three measures of gambling intensity were recorded – participants' betting speed (average amount of time taken to place bets, measured in seconds), expenditure (average number of credits bet per game) and risk-taking (average number of credits placed on high-, medium- and low-risk bets). Table 1 (adapted from Dixon et al., 2007) shows the types of bets associated with each risk level, and their associated probabilities, payouts, and expenditures. Online screen recording software was employed to permit participants to gamble alone and capture participants' computer activity.

INSERT TABLE 1 HERE

Experimental Questionnaire

The questionnaire collected demographic data (age and gender), opinions of the musical stimuli, information about participants' gambling habits (frequency of gambling and gambling expenditure) and participants' problem gambling status via the completion of the Problem Gambling Severity Index (PGSI, Ferris & Wynne, 2001).

The PGSI consists of nine questions and participants responded to each on a scale (0 = Never; 1 = Sometimes; 2 = Most of the time; 3 = Almost Always). Scores obtained for each question were totalled to provide participants' problem gambling status (0 = Non-problem gambler; 1–2 = Low-risk gambler; 3–7 = Moderate-risk gambler; 8+ = Problem gambler).

Participants rated their agreement with four statements about the musical stimuli using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The statements examined concepts of liking, fit, familiarity and whether the musical stimuli aided concentration during the gambling task.

Arousal

Both music and gambling are known to influence arousal independently. Therefore physiological data (HR and SCL) were collected during the gambling task using a ProComp5 Infinity encoder and sensors. HR was measured using a sensor attached to participants' middle finger (sample rate of 2048 s/s) and SCL was measured using sensors attached to participants' index and ring fingers of the hand that was not using the mouse (sample rate of 256 s/s). Baseline measures of HR and SCL were collected when participants sat alone and in silence for two minutes, following the familiarisation period (see Main Study Procedure). Physiological arousal was measured continuously during the gambling task. Mean HR and SCL calculated for the baseline and during gambling periods were used for analysis. The three-dimensional model of affect (Schimmack & Grob, 2000) measured subjective valence, arousal and tension prior to (baseline) and following the experiment (post-gambling).

Participants

One hundred and forty-four participants took part in this study and comprised an opportunity sample of staff and students from The University of Sheffield. Participants were either undergraduate psychology students who completed the experiment in return for course credit or volunteers from the university population. Data were incomplete from seven participants, therefore the final sample size was 137 participants (88 female; M age = 20.9 years, range 18–51, SD = 5.7). Participants were randomly assigned to one of three conditions. Forty-seven participants completed the “no music” condition (32 female); 43 participants completed the “slow tempo music” condition (29 female) and 47 participants completed the “fast tempo music” condition (27 female). Neither age, $F(2,85.67) = 1.52$, $p > .05$ (Welch’s ANOVA), nor gender distribution, $\chi^2(2) = 1.32$, $p > .05$, significantly differed between conditions. A chi-square analysis found no bias between conditions according to the distribution of gamblers and non-gamblers $\chi^2(2) = .85$, $p > .05$. All but 7 participants completed the PGSI – 102 participants were classified as non-problem gamblers, 22 as low-risk gamblers, 12 as moderate-risk gamblers and 1 participant was identified as a problem gambler. PGSI classification did not significantly differ between conditions ($p = .67$, Fisher’s Exact Test). Participants took on average 9 minutes and 35 seconds (SD = 1.23) to play ten games of roulette. The amount of time spent gambling did not differ between conditions $F(1,134) = 2.06$, $p > .05$.

Procedure

Participants were tested individually and sat at a computer running the virtual roulette game (via http://www.dublinbet.com). Participants read the information sheet and gave their informed consent.

Participants received instructions verbally about the rules and objective of roulette, the prize draw and how to operate the virtual roulette game. To encourage competition, ten participants with the highest credit balance at the end of the experiment were entered into a prize draw for a £25 Amazon gift voucher.

During a familiarisation period, participants played three practice games of roulette. Following this, the experimenter left the room and the baseline measure of physiological arousal was taken. The experimenter then returned and participants completed the baseline measure of subjective arousal. The experimenter then started the CD player and left the room. The complete versions of the musical stimuli (each 13 minutes in duration) were presented via a high quality CD sound system and speakers in a soundproofed room. The volume of the musical stimuli was kept constant between participants but the dynamic changes within the stimuli were retained. The level of intensity of the musical stimuli ranged from 52dB to 73dB. Participants began betting once "Place Your Bets" appeared on the screen until "No More Bets" appeared. After this, the roulette wheel was spun and the number and colour of the winning slot appeared on the screen together. This cycle continued for the 13-minute duration of the gambling session. However, if participants had spent their allotted credits, then they waited in the room until the experimenter re-entered.

Betting speed for each game was recorded from when the screen displayed "Place Your Bets" until participants stopped placing bets, as indicated by their final mouse click. The time stamp of the video recording was used to measure betting speed. The video file was also used to record expenditure and risk taking. To enable the results to be compared with those obtained by previous studies, subjective and physiological responses during the first ten games were used for analysis (Bramley et al., 2014; Dixon et al., 2007).

Following the gambling task, the experimenter entered the room and the participants completed the post-gambling measure of subjective arousal and the Experimental Questionnaire. Finally, participants were given an advice sheet listing organisations should they wish to discuss their gambling habits.

Results

Gambling behaviour

As shown in Table 2, similar means were obtained for betting speed and expenditure across conditions. Participants spent the most credits on high risk bets during the no music condition and spent the most credits on medium risk and low risk bets when listening to fast tempo music compared to the other two conditions. One-way ANOVAs (between-participants) found that condition did not influence betting speed, $F(2,134) = .099$, $p > .05$, expenditure, $F(2,134) = .16$, $p > .05$, high risk bets, $F(2,134) = .05$, $p > .05$), medium risk bets, $F(2,134) = .05$, $p > .05$, or low risk bets, $F(2,134) = .18$, $p > .05$.

INSERT TABLE 2 HERE

Opinions of the musical stimuli

A series of independent samples t-tests found that tempo did not significantly influence participants' opinions of the musical stimuli in relation to liking, $t(88) = -.3$, $p > .05$; familiarity, $t(88) = -.022$, $p > .05$; concentration, $t(88) = -.84$, $p > .05$, or fit, $t(88) = -.30$, $p > .05$ (see Table 3).

INSERT TABLE 3 HERE

Arousal

Table 4 shows the means obtained for the indices of physiological arousal and subjective valence, tension and arousal by time of measurement and condition. The physiological data were screened, and movement artefacts or extreme values were removed prior to analysis. Data from nine participants (2 from the “no music”, 3 from the “slow tempo music” and 4 from the “fast tempo music” conditions) were excluded from analysis of the physiological arousal data because there were a large number of movement artefacts at baseline or during gambling thus their responses could not be compared.

Mixed-design ANOVAs with one within-subjects variable (time of measurement – baseline versus during gambling) and one between-subjects variable (condition) were used to test the effect of music condition on the various measures of physiological arousal and subjective valence, tension and arousal. HR was significantly higher during gambling than at baseline, $F(1,125) = 32.31$, $p < .05$. No main effect of condition on HR was observed, $F(2,125) = .66$, $p > .05$, and time of measurement and condition did not interact, $F(2,125) = .39$, $p > .05$. SCL was significantly higher during gambling than at baseline, $F(1,125) = 131.84$, $p < .05$. There was no effect of condition on SCL, $F(2,125) = 1.68$, $p > .05$ and no interaction, $F(2,125) = 2.95$, $p > .05$.

With regards to subjective valence, tension and arousal the final sample size was 136, due to missing data from one participant from the fast tempo music condition. Subjective valence was not significantly influenced by condition, $F(2,133) = 1.39$, $p > .05$, or time of measurement, $F(1,133) = .25$, $p > .05$, or by their interaction, $F(2,133) = .19$, $p > .05$. There was no main effect of condition on tension $F(2,133) = 1.36$, $p > .05$, but a significant main effect of time of measurement was observed, $F(1,133) = 7.60$, $p < .05$. Subjective tension was higher post-gambling compared to baseline. Time of measurement and condition did not interact, $F(2,133) = .43$, $p > .05$. For subjective arousal, no main effect of condition was found, $F(2,133) = .33$, $p > .05$. However a significant main effect of time of measurement was observed, $F(1,133) = 33.79$, $p < .05$, as subjective arousal was higher post-gambling compared to at baseline. No interaction between time of measurement and condition was observed, $F(2,133) = .45$, $p > .05$.

INSERT TABLE 4 HERE

Discussion

This study investigated whether fast tempo music influences gambling via an effect on arousal using a laboratory virtual roulette task. In this situation, in which musical attributes other than tempo were controlled, music tempo alone did not influence indices of gambling behaviour or arousal.

The absence of an effect of music's presence on laboratory virtual roulette gambling behaviour is not consistent with findings obtained by Dixon et al. (2007), who found that the mere presence of music led to betting speed being significantly quicker (fast tempo music condition) or slower (slow tempo music condition) than the "no music" condition. Given that the gambling task utilised within the present study was similar to that used by Dixon et al. (2007), the difference in results may be attributed to differences within the musical stimuli presented to participants. First, Dixon et al. (2007) utilised stimuli described as upbeat dance music (fast tempo condition) and chill-out dance music (slow tempo condition). "Chill-out" is characterised as music which "shouldn't draw too much attention...ideally be the type of inoffensive music that most people could sit back and relax to" and "a flowing groove" (Snoman, 2004: 254–256). Participants may therefore have experienced a change in arousal or mood relative to the other conditions, which influenced their betting speed. However Dixon et al. (2007) did not measure participants' mood, emotional responses or arousal level either prior to, during or after the gambling task. Therefore it is difficult to conclude whether music-induced mood, emotion or arousal led to the observed influence of music on betting speed. Second, the present study was the first since Dixon et al. (2007) to include a "no music condition" when examining music's influence on laboratory virtual roulette gambling behaviour and the results suggest that the mere presence of music does not influence betting speed, expenditure or risk-taking. The results raise the possibility that influences of music on virtual roulette gambling behaviour might only be elicited by certain musical stimuli rather than by the mere presence of any music.

Music tempo and gambling

Consistent with previous research, music tempo did not influence risk-taking or expenditure, even when, in this case, other musical attributes were controlled. However, the absence of an effect of music tempo alone on betting speed is not consistent with previous research and suggests that music's effects on betting speed obtained in previous research may have been misattributed to tempo. It is likely that music's effects on betting speed in previous research are due to other musical features which confounded with tempo in those other experimental stimuli.

Music tempo and arousal

The results of the pre-study suggested that fast tempo music increased subjective arousal; however this effect did not transfer to the main study either in the measures of subjective or physiological arousal. In the pre-study the music was presented alone, whereas during the main study the music was heard whilst participants completed the gambling task. Furthermore, music's presence may have shifted from the foreground (in the pre-study) to the background (in the main study). Therefore the music may have been more salient during the pre-study compared to the main study where the introduction of the gambling task in the main study may have diverted participants' attention away from the music and towards gambling.

Five reasons for why tempo did not influence arousal in the main study are proposed. First, effects of tempo on measures of arousal may be mediated by concurrent task demands. Music can influence behaviours such as driving (Brodsky, 2002, experiment 1) and copying text (Van der Zwaag et al., 2011) in the absence of changes in physiological arousal. In contrast HR increased when cycling and listening to fast tempo music (Waterhouse et al., 2010). The amount of movement that is required to drive, copy text and cycle differs, therefore it may be that music tempo's ability to influence indices of physiological arousal is mediated by the amount of physical exertion demanded by the task. Music tempo alone may not have influenced arousal levels in the present study perhaps because of the minimal movement involved in playing laboratory virtual roulette.

Second, it may be that heart rate is not a reliable measure of physiological arousal responses to music tempo in this particular situation. Heart rate has frequently been recorded in studies examining physiological responses to music; with many studies finding that music leads to changes in heart rate (see Hodges, 2009 for a review). However Ellis (2009) compared changes in mean HR and heart rate variability (HRV, degree of fluctuation in beat-to-beat heart rate) while subjects listened to 2.5-minute excerpts of music at three different tempos (60, 90, 120bpm). Mean HR did not change significantly. HRV, on the other hand, decreased as tempo increased, indicating a withdrawal of parasympathetic nervous system activity (Ellis, 2009). Therefore future studies may wish to measure physiological arousal using HRV in order to examine whether HRV is a more sensitive measure of arousal from music (Ellis & Thayer, 2010).

Third, it is possible that the manipulation of tempo alone was not sufficient to induce arousal changes in the context of gambling. Research which has examined tempo's effect on physiological arousal has tended to use different musical pieces to represent different tempi, thereby confounding changes in tempo with changes in other musical attributes which may also contribute to induced arousal (e.g., Bernardi Porta, & Sleight, 2006; Carpentier & Potter, 2007; Coutinho & Cangelosi, 2011; Gomez &

Danuser, 2007; Iwanaga & Moroki, 1999; Iwanaga, Ikeda & Iwaki, 1996; Weld, 1912). The results of the present study suggest that tempo alone (or at least with this degree of differentiation in bpm) may not be able to induce changes in physiological arousal during a gambling task. With regards to subjective arousal, two studies which manipulated tempo alone employed stimuli that had a slow music tempo of 60 bpm (Balch & Lewis, 1996; Husain et al., 2002), and fast music tempi of 165 bpm (Husain et al., 2002) and 140 bpm (Balch & Lewis, 1996), respectively, but the studies did not examine gambling behaviour. Based on the tempi used in these two studies we speculate that for a change in subjective arousal to be induced in the present study, the tempi of the fast and slow musical stimuli would have had to differ by at least 80 bpm.

Fourth, it may be that any effect of tempo on arousal (physiological or subjective) was curtailed or subsumed by the effects of the task on arousal. This study confirms the findings of previous research which has suggested that gambling elicits changes in physiological (Anderson & Brown, 1984; Coulombe et al., 1992; Coventry & Hudson, 2001; Diskin et al., 2003; Leary & Dickinson, 1985) and subjective arousal (Diskin & Hodgins, 2003; Diskin et al., 2003; Leary & Dickinson, 1985). The significant effects of gambling on HR, SCL, subjective arousal and tension levels may therefore have masked or restricted any potential effects of tempo on these same measures of arousal.

Fifth, tempo did not influence participants' opinions of the musical stimuli in relation to familiarity, liking, concentration or fit. Such findings are consistent with previous research – Bramley et al. (2014) found that tempo did not influence participants' judgements of fit. The present study's findings also suggest that tempo alone does not influence participants' self-reported concentration, which concurs with findings obtained by Dixon et al. (2007). Consequently, it appears that experimenter-selected music which differs in tempo alone does not influence participants' judgements in this particular laboratory gambling situation.

Limitations

One limitation relates to the study's design. As only one set of musical stimuli and one set of tempi were tested, one cannot rule out that the utilisation of a higher tempo for the fast condition and a lower tempo for the slow condition may have led to music tempo alone influencing betting speed. Future studies could explore this using more extreme tempo manipulations and different musical compositions. Two other limitations relate to whether the study's findings can be generalised to real-life gambling situations. First, participants gambled with credits and this may have inadvertently influenced expenditure. Gambling with chips or credits can increase expenditure, possibly because the psychological value of chips or credits is less than real money (Lapuz & Griffiths, 2010). Second, the absence of winning or losing money may have led participants to view the gambling task as unrealistic and unrepresentative of a real-life gambling situation, in turn participants may have altered their gambling behaviour, although this was mitigated by participants being offered the opportunity to be entered into the prize draw. These limitations highlight the need for future research to be conducted with individuals in situ.

Conclusions

Despite these limitations, this study contributes to the fields of music psychology and gambling studies because it suggests that there are some tasks and musical characteristics under which tempo is less likely to influence behaviour. The study indicates three directions for future research. First, future studies could investigate whether arousal mediates effects of tempo on behaviour by using a potentially more sensitive measure of physiological arousal, such as HRV. Second, future research could manipulate musical attributes of stimuli, such as loudness, pitch or more extreme tempi, as they might prove to be more successful ways to induce arousal in participants. Third, more research is needed to investigate whether self-selected music influences aspects of gambling behaviour, as it does in other activities (Herrington & Capella, 1996). This idea is prompted by research indicating that gamblers self-select music to accompany gambling, particularly moderate-risk and problem gamblers, which in turn supports cognitive and emotional aspects of gambling (Bramley, 2015). This type of music may perform different functions from, and use difference mechanisms than experimenter-selected music. In conclusion, our findings provide an insight into the limits of music tempo as an explanation for music effects on behaviour.

Ethical Approval

Ethical approval for this project was given by The University of Sheffield.

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