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Effects of musical valence on the cognitive processing of lyrics

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Abstract

The effects of music on the brain have been extensively researched, and numerous connections have been found between music and language, music and emotion, and music and cognitive processing. Despite this work, these three research areas have never before been drawn together into a single research paradigm. This is significant as their combination could lead to valuable insights into the effects of musical valence on the cognitive processing of lyrics. This research draws on theories of cognitive processing suggesting that negative moods facilitate systematic and detail-oriented processing, while positive moods facilitate heuristic-based processing. The current study (n = 56) used an error detection paradigm and found that significantly more error words were detected when paired with negatively valenced sad music compared to positively valenced happy music. Such a result explains previous findings that sad and happy lyrics have differential effects on emotion induction, and suggests this is due to sad lyrics being processed at deeper semantic levels. This study provides a framework in which to understand the interaction of lyrics and music with emotion induction – a primary reason for listening to music.

Keywords

cognitive processing, emotion, lyrics, music, semantic errors, valence

Music, language, and emotion are three integral parts of the human experience that share many interesting connections, and their combination can reveal much about human cognition. The fields of music and language research (e.g., Koelsch et al., 2002; Patel, 2008), and music and emotion research (e.g., Juslin & Sloboda, 2010) have so far progressed quite separately. Moreover, most research into music and emotions has not considered music with lyrics (Brattico et al., 2011). Consequently, the emotional effect of the combination of music and lyrics on cognition is not well understood.

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The few studies that have investigated the cognitive processing of music, lyrics and emotion suggest that the valence of the music (positive or negative) affects how lyrics and music interact. In one study, Ali and Peynircioğlu (2006, Experiment 1) asked participants to rate the emotional connotation of happy, sad, angry and calm music played with and without lyrics. For happy and calm melodies, participants gave higher ratings of the intended emotion when there were no lyrics; however, for sad and angry melodies, participants gave higher ratings of the intended emotion when there were lyrics. The authors argued that lyrics *enhanced* the perception of sadness, but *detracted* from the perception of happiness, suggesting that the effect of lyrics on perceived emotion was dependent on the valence of the music. Experiment 2 of the same study was designed to identify whether lyrics or music were more important in conveying emotion, and consisted of congruent and incongruent pairings of music and lyrics. Melody appeared more dominant than lyrics in the perception of emotion; however, ratings were highest for the intended emotion when the music and lyrics were *congruent*. This shows that both music and lyrics are important in emotion perception, and suggests that congruent music and lyrics may be especially effective for mood induction.

Further addressing this issue, a more comprehensive study by Brattico et al. (2011) employed functional magnetic resonance imaging (fMRI) to investigate the combination of lyrics and music on emotion induction. The authors found much more extensive brain activations in response to sad music *with* lyrics, and to happy music *without* lyrics, compared to sad music without lyrics and happy music with lyrics, particularly in the limbic system (the emotion centre of the brain). Interestingly, sad music with lyrics activated Brodmann area 47 (an area that specialises in processing both music and language syntax) to a greater extent than happy music with lyrics. These findings led the authors to the conclusion that these combinations of music and lyrics are experienced at a deeper level in the brain than their counterparts, which could help interpret Ali and Peynircioğlu's (2006) findings.

Music, language and emotion

The connections between music and lyric processing in relation to emotion are perhaps not surprising given connections previously identified between both music and language and music and emotion. Connections between music and language have received much attention from evolutionary psychologists (e.g., Mithen, 2009), neuroscientists (e.g., Koelsch et al., 2002), and psychologists (e.g., Patel, 2008). Music and language have been found to draw on similar processing mechanisms (Koelsch et al., 2002; Patel, Gibson, Ratner, Besson, & Holcomb, 1998), and show similarities in terms of perception (Bidelman, Gandour, & Krishnan, 2011), semantics (the meaning inherent in the language/music: Koelsch et al., 2004), syntax (the rules of the structure, e.g., grammar/note-hierarchies: Fiveash & Pammer, 2014; Maess, Koelsch, Gunter, & Friederici, 2001) and transfer effects (Besson, Chobert, & Marie, 2011). The similarities in structures, hierarchies and rules governing the creation of both language and music have also been compared (Johansson, 2008). Strong evolutionary links between the two domains have been identified, with music often considered as a precursor to language and communication (Mithen, 2009). Furthermore, both music and language are considered universal human traits across cultures (Peretz, 2006).

Research into music and emotion is also complex, since understanding emotions induced and perceived through music involves a range of factors, including untangling connections between the music, the listener, and the situation; the measurement of emotion; and deciphering the subjective nature of human emotions (Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; Juslin & Sloboda, 2010). While the general consensus is that music can induce strong emotions (Juslin & Sloboda, 2010; Lundqvist, Carlsson, Hilmersson, & Juslin, 2009), and that a primary reason people listen to music is to induce emotions (Juslin & Laukka, 2004), the types of emotions that can be induced, differences between induction and perception of emotion in laboratory settings, and even the definition of "emotion" itself, is still under debate (Juslin & Västfjäll, 2008). While this is so, research into the effects of musically induced emotions has yielded some compelling results (see Juslin & Sloboda, 2010), especially in relation to subsequent cognitive processing.

Emotion and cognitive processing

The effects of positive and negative mood on the processing of stimuli have been well documented (Mitchell & Phillips, 2007), and it is commonly found that cognitive processing is influenced by mood. In particular, a number of researchers have suggested that negative moods lead to systematic, analytic, detail-oriented and local-level processing; while positive moods lead to heuristic processing (using mental shortcuts), less focused attention, higher creativity and global-level processing (Beukeboom & Semin, 2006; Bless & Fiedler, 2006; Forgas, 2008, 2013; Gasper & Clore, 2002; Matovic, Koch, & Forgas, 2014). A strong theory in this field is Bless and Fiedler's (2006) assimilation/accommodation theory. This theory suggests that negative mood facilitates the externally driven process of *accommodation*, where external stimuli are processed in a systematic, bottom-up manner. Alternatively, positive mood facilitates the internally driven process of *assimilation*, where external stimuli are processed using heuristics and in a top-down manner (see Bless & Fiedler, 2006). This theory has been supported by a number of empirical studies. Most relevant to the current study are the connections found between affect and language processing.

Musically induced emotions, and transient mood states, have been shown to affect cognitive processing, and language processing in particular. Studies have shown mood congruence effects on narrative recall (Tesoriero & Rickard, 2012) and faster word processing for congruent information (Olafson & Ferraro, 2001). In addition to mood congruence effects, research has also shown that priming a mood can affect the way subsequent information is processed. By inducing sadness in participants through both music and the recollection of autobiographical memories, Vuoskoski and Eerola (2012) found that both memory and judgement for emotion related stimuli were affected. Furthermore, Jiménez-Ortega et al. (2012) found that the processing of neutral sentences differed significantly depending on whether a priming paragraph was positive or negative. They found that positive priming paragraphs led to lower error detection and higher reaction time for semantic and syntactic errors, compared to negative priming paragraphs. This suggests that transient mood states, or priming, can affect the way language is processed.

Similar effects have been shown in the neuroimaging literature. Federmeier, Kirson, Moreno, and Kutas (2001) used EEG to show that mood can influence language processing in terms of semantic memory retrieval. Federmeier et al. (2001) used pictures to induce positive or neutral mood, and then presented participants with sentences ending with: (a) the most expected ending; (b) an unexpected ending, but with a word in the same semantic category; or (c) an unexpected ending from a different semantic category. As this was a within-subjects design, the authors were able to show that different brain activations occurred in the same participants depending on whether they were in a neutral or positive mood, clearly showing that mood influences the way our brain responds to semantic stimuli. They concluded that transient mood states affect online semantic processing. Vissers et al. (2010) also identified an interaction between mood and the P600 brain response elicited with syntactic anomalies in language, suggested to be due to different processing strategies being employed in different mood conditions. This suggests that transient mood states, or priming, can affect the way language is processed. It could therefore be speculated that the valence of music would affect the way that lyrics paired with it are processed.

Such differences between positive and negative affect can help to explain why lyrics appear to play a different role in emotion induction depending on the valence of the music. It could be hypothesised that by inducing positive emotions in listeners, positive music leads to less focused attention, and a greater use of heuristic techniques. By extension, this would thereby lead to less focus on the semantic content of the lyrics. When the music is negative, however, this could be hypothesised to activate more focused, analytic and detailed processing. This would lead to the lyrics being processed at a deeper level when paired with sad music. While such an explanation was not considered in Brattico et al.'s (2011) study, it is possible that the valence-dependent difference in emotion induction identified was due to transient mood states altering the way lyrics were processed.

The current study

The current research question is whether musical valence (positive or negative) affects the processing of mood-congruent lyrics, due to different cognitive processing strategies being activated depending on the induced mood. For current purposes, happy and sad music was used to exemplify positive and negative affect. To measure cognitive processing of lyrics, an error detection paradigm was used, and participants were asked to detect semantic errors in the lyrics of songs with positive or negative valence. Semantics refers to the meaning inherent in structures – such as music and language. Semantic (as opposed to syntactic) violations were chosen because of the emotional nature of the stimuli. The error detection paradigm is similar to that used by Jiménez-Ortega et al. (2012), and is a reflection of cognitive processing and attention. The hypothesis of the current study is that detection of semantic errors in lyrics paired with happy music will be lower than the detection of semantic errors in lyrics paired with sad music. This is based on research suggesting that negative moods lead to more detailed, analytic, and systematic modes of processing (Bless & Fiedler, 2006; Forgas, 2013; Mitchell & Phillips, 2007), which would in turn lead to more errors being identified. This hypothesis draws from studies showing that music and language share similar processing resources and are mutually influential (Patel, 2008); that mood influences language processing (Vissers et al., 2010); and that music can induce strong emotions or moods in listeners (Juslin & Sloboda, 2010). The purpose of this study was therefore to investigate how music-induced transient mood states affect the processing of lyrics, and how this in turn affects the interaction of music and lyrics depending on the valence of the music.

Method

To test the hypothesis that happy music leads to lower levels of error detection in lyrics, and sad music leads to higher levels of error detection in lyrics, an online questionnaire was designed using Qualtrics (Qualtrics Software, Version 55581; http://www.qualtrics.com), and distributed via social media.

Participants

A total of 76 participants were tested. Due to significantly lower performance for non-native English speakers (n = 19), these participants were not included in the analyses. Two participants did not detect any errors in either the happy or sad music conditions and so these were also excluded. This left 56 native English speakers in total (37 women, 19 men, M_{age} = 31.25 years, age range 18–72 years) who completed the online questionnaire. Participants who rated themselves as bilingual (n = 3) are referred to here as native English speakers. Participants also rated themselves on level of musicianship (27 non-musicians; 29 musicians). Fifty of the participants reported wearing headphones during the experiment.

Stimuli

The questionnaire presented participants with 40 one-minute original songs consisting of both music and lyrics. Of these, 20 were happy (exemplifying positive affect), and 20 were sad (exemplifying negative affect), with mood-congruent lyrics. The lyrics were congruent with the valence of the music to enhance the likelihood of mood induction (Ali & Peynircioğlu, 2006; Hunter, Schellenberg, & Schimmack, 2010). Each song had a music-only introduction of approximately 15 seconds. The music was composed according to guidelines on what constitutes happy and sad music – most importantly, tempo and mode (Juslin & Laukka, 2004). Sad songs were in minor keys and averaged 80 beats per minute (bpm), while happy songs were in major keys and averaged 140 bpm. Both the happy and sad songs had an average of 55 words per song. The songs were in commonly used musical keys, and the number of examples from each of these keys was roughly equal (see Appendix A). The lyrics followed happy or sad themes. The songs were recorded in a professional studio, sung by the composer to enhance emotional expression, and played on an acoustic Landola nylon string guitar. Vocals were recorded with an Audio Technica 4033 microphone, and the guitar was recorded on a Royer R122 Ribbon microphone. Minimal effects were added to the recordings. Examples of happy and sad song lyrics and chords are shown in Figure 1.

Semantic errors

Half of the songs were randomly selected to contain a semantic error in the lyrics. Songs were randomised within the happy and sad conditions, resulting in ten happy and ten sad songs being selected to contain a semantic error. A random word was then selected to be changed. If the word was not suitable for changing or the word was one that was sung too quickly, then the closest suitable word was chosen instead. Words that were not suitable for changing were connecting words such as “the”, “a” etc., as they hold minimal semantic meaning. Semantic error words were chosen from the Medical Research Council (MRC) Psycholinguistic Database (Coltheart, 1981; http://websites.psychology.uwa.edu.au/school/MRCDatabase/uwa_mrc.htm). Words were generated that started with the same letter, and had the same number of syllables as the word that was to be replaced. From this list, a word that fit musically but did not make semantic sense within the sentence was chosen. All songs were pilot tested to ensure they portrayed the intended emotion, and that the error words were noticeable.

Design

In the online questionnaire, participants read the following instructions: “You will be presented with 40, one-minute songs. Half of these will be positive sounding, and half of these will be negative sounding. Some of the lyrics in the songs will have errors in them – words that do not fit into the context of the song. At the end of each song, you will be asked (1) was there an error a)

Intro – Bm, F#m
Bm F#m
This was the first time
Bm F#m
I'd lost someone, so dear
Bm F#m
This was the first time,
Bm F#m
Now grief becomes clear

D Bm F#m
The sad song plays, as they carry you away
D Bm F#m
To another place, I don't know the name

Bm F#m Bm F#m
Family *watch* **WIPE** on, I can't believe you're actually gone
Bm F#m
Cause, this was the first time,
Bm F#m
This was the first time...

b)

Intro – D C G
D C G D C G
I'm standing at the airport, waiting for you
D C G D C G
The other *loved* **LYNCH** ones stand here too
D C G
From behind, someone starts singing,
D C G
Up ahead, people start dancing,
D C G D C G
All around, music's being made

D C G
A little bit of drums, to start the beat,
D C G
People dancing, moving their feet
D C G
Trumpet from the corner, now it's complete,
D C G D
Everyone moving, moving their feet

Figure 1. Examples of sad and happy song stimuli. Error words are in capital letters and replaced the italicised words; (a) is a sad song with 56 words played at 84 bpm; (b) is a happy song with 56 words played at 144 bpm.

in the lyrics? And (2) if there was an error, what was the error word?" Participants were reminded that participation was voluntary and confidential, and that they were able to withdraw from the study at any time.

To measure whether the stimuli were able to induce positive and negative moods in the participants, the Positive and Negative Affect Schedule (PANAS: Watson, Clark, & Tellegen, 1988) was administered three times: before listening to any stimuli (baseline); after listening to the happy stimuli; and after listening to the sad stimuli. The PANAS is a 20-question measure of affect that consists of a ten-question positive affect scale and a ten-question negative affect scale. It is shown to be reliable, internally consistent, and the scales are not correlated with each other (Watson et al., 1988). The PANAS was chosen because it is a short, well-known measure of affect, and has been listed as one of the most used scales in the study of musical emotions (Juslin & Sloboda, 2010). Participants were asked to "indicate to what extent you feel this way right now, that is, at the present moment", when rating the different affect measures. Due to the scale measuring *current* positive and negative affect, this was considered a good way to measure transient mood states.

Following the baseline PANAS measurement, stimuli were presented in blocks of 20 songs. Happy and sad songs were grouped together within these blocks to increase the likelihood of mood induction. Presentation order of the two blocks was counterbalanced. Within these blocks, the songs themselves were randomised to counteract fatigue and practice effects. After each song, participants were asked if they detected an error and to report it if so. After completing the experiment, participants were thanked for their time, and if they had listened to the sad songs last they were told to listen to a happy song to cheer themselves up.

Table 1. Scoring system.

Condition	0	1	2	3
Error	Didn't identify an error	Identified error, but gave wrong error word	Answer rhymed with correct error word	Identified error word
No error	Incorrectly identified presence of error	Correctly identified absence of error		

Scoring system

A scoring system was devised to encapsulate all possible answers. For the stimuli with an error word, a score of zero meant that the participant did not identify an error. A score of one meant that they identified an error, but either gave the wrong word or gave no answer. A score of two meant that they identified a word that rhymed with the error word. A score of three meant that they gave the correct error word (different spellings/phonetic spellings were accepted). For songs with no error, a score of zero was given if the participant said there was an error when there was not, and a score of one was given if the participant correctly said there was no error. This scoring system is shown in Table 1. Overall happy and sad error detection scores were then calculated so that each participant had one score for happy and one score for sad error detection.

Results

It was hypothesised that more error words would be identified in sad songs compared to happy songs, due to a more detailed, local level of cognitive processing being utilised when participants were in a more negative mood.

Mood induction

To ensure the intended moods were induced, a 2 x 3 repeated-measures analysis of variance (ANOVA) was run with the factors Mood (positive, negative), and Time (baseline, after happy songs, after sad songs), and a between-subjects variable of Order (happy songs heard first, sad songs heard first). There were main effects of Mood: $F(1,54) = 54.14$, $p = .0001$, partial $\eta^2 = .501$; and Time: $F(2,108) = 20.67$, $p = .0001$, partial $\eta^2 = .277$. There was also a significant Mood x Time interaction effect: $F(2,108) = 19.37$, $p = .0001$, partial $\eta^2 = .264$. There were no significant interaction effects of Mood x Order: $F(1,54) = 0.554$, $p = .460$, or Time x Order: $F(2,108) = 2.89$, $p = .06$, suggesting that the order in which the songs were presented did not affect the results. These results are shown in Figure 2.

Positive affect

Planned pairwise comparisons with Holm–Bonferroni corrections were run to see where the differences between the groups lay. For the positive affect scores, there were significant differences between each time point. Positive affect was significantly lower after sad songs ($M = 19.47$, $SD = 8.01$) compared to baseline ($M = 25.11$, $SD = 8.46$), $t(55) = 7.21$, $p = .0001$. Positive affect was also significantly lower after sad songs compared to after happy songs ($M = 23.46$, $SD = 9.43$), $t(55) = 4.48$, $p = .0001$. These two findings suggest that positive affect decreased when

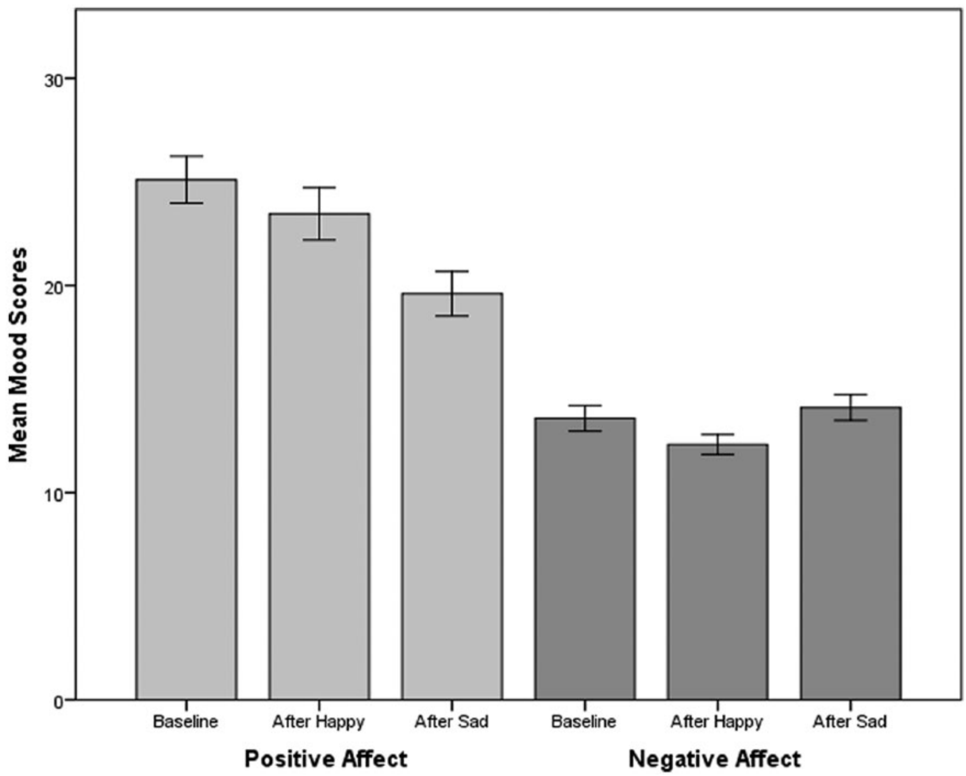

Figure 2. Mood ratings from PANAS at baseline, after happy songs, and after sad songs for both positive and negative affect. Error bars represent mean standard error.

participants listened to the sad songs compared to when they listened to the happy songs. There was, however, a significant decrease in positive affect after happy songs compared to baseline, $t(55) = 2.60$, $p = .012$. This decrease is likely due to fatigue and boredom effects from sitting in front of the computer. The main result of note is therefore the decrease in positive affect after sad songs compared to after happy songs.

Negative affect

Holm–Bonferroni corrected pairwise comparisons indicate that negative affect significantly decreased after happy songs ($M = 12.32$, $SD = 3.61$) compared to baseline ($M = 13.59$, $SD = 4.65$), $t(55) = 2.54$, $p = .014$. Negative affect also significantly increased after sad songs ($M = 14.11$, $SD = 4.67$) compared to after happy songs, $t(55) = 3.61$, $p = .001$. There was no significant difference in negative affect between baseline and after sad songs, $t(55) = .93$, $p = .354$. This shows that negative affect was significantly higher after participants listened to sad songs compared to happy songs, and that negative affect was significantly lower compared to baseline after participants listened to happy songs. The combination of the positive and negative affect scores of the PANAS scale therefore strongly suggests that the intended moods were in fact induced. All of these results are shown in Figure 2.

Happy and sad error word conditions

The overall scores for the happy and sad conditions were scored as outlined above in the "Scoring system" section of this article. This led to a "TotalHappy" and a "TotalSad" score for each participant, based on the identification of both error words and lack of error words. It was therefore a measure of accuracy, reflecting attention and cognitive processing. A repeated-measures ANOVA was run to test whether participants were more likely to recognise error words in the happy or sad condition. The total scores for happy and sad were compared (TotalHappy: M = 1.25, SD = 0.34; TotalSad: M =1.41, SD = 0.34) and the difference was found to be significant, $F(1,55)$ =14.84, p = .0001, partial η^2 = .21.

In addition, to test whether false positives (reporting an error when there was no error) were more common in the happy or sad condition, the scores for songs with no error words were averaged for each participant. A repeated-measures ANOVA was then run on the happy and sad scores for songs with no error (score of 1 = participant said there was no error; score of 0 = participant said there was an error when there was not). The difference between the happy (M = 0.88, SD = 0.16) and sad (M = 0.95, SD = 0.09) conditions was significant: $F(1,55)$ = 15.03, p = .0001, partial η^2 = .22 with participants giving false positive answers more often in the happy condition. Combined with the main effect that participants detected more errors in the sad condition, this result is suggested to be due to less detailed, heuristic processing, and a higher likelihood of participants guessing in the happy condition (as found in Bless et al., 1996).

Musical ability

A mixed-design ANOVA was run with TotalHappy and TotalSad as the within-subject factors, and musical ability (musician, n = 29; non-musician, n = 27) as the between-subjects factor. There was no significant main effect of musical ability, $F(1,54)$ = 2.12, p = .151, and no interaction between the scores and musical ability, $F(1,54)$ = 0.626, p = .434, suggesting that musicians and non-musicians performed similarly.

The stimuli

To ensure the stimuli were comparable in each condition, a number of parameters were tested. The spread of scores for songs with error words can be seen in Figures 3a and 3b. It can be seen that the range of scores (for the happy condition error songs only, range = 1.83; for the sad condition error songs only, range = 1.8) are comparable, and visually the two conditions have a similar distribution. This suggests that the level of difficulty and the variance within songs were similar, and thus that the effect was due to the condition (sad or happy), rather than a difference in difficulty of detecting error words.

To further ensure that differences between groups were not due to differences in stimuli, an independent-samples t-test was run for the word count of the songs in each condition. It was found that the number of words for songs in the happy (M = 55.15, SD = 5.69) and sad (M = 55.2, SD = 5.59) conditions was not significantly different: $t(38)$ = 0.28, p = .98.

To check that the error word positions within the songs were not significantly different for the happy (M = 33.3, SD = 13.47) and sad (M = 27.4, SD = 15.01) conditions, an independent-samples t-test was run, which was also not significant: $t(18)$ = 0.925, p = .37.

To check that there was no effect of the error word's position in the sentence, a final independent-samples t-test was run, which found no significant difference between the positions of

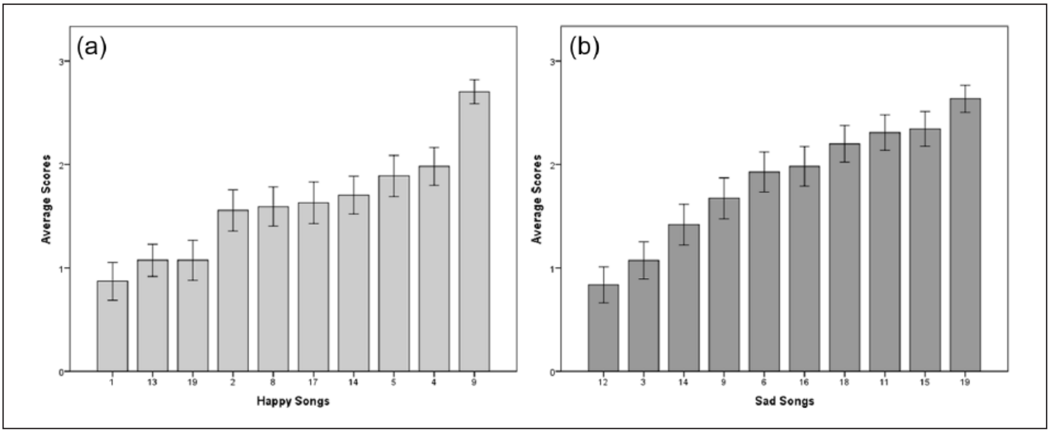

Figure 3. (a) Average scores on each song with an error in the happy condition; (b) average scores on each song with an error in the sad condition. Error bars represent mean standard error.

words in a sentence in the happy condition ($M = 4.1$, $SD = 1.66$) compared to the sad condition ($M = 4.0$, $SD = 2.05$), $t(18) = 0.12$, $p = .91$. These results suggest that the findings were due to the valence of the song, and not to differences in stimuli between conditions.

Discussion

The current study tested and confirmed the hypothesis that detection of error words should be greater for lyrics paired with negatively valenced sad music compared to lyrics paired with positively valenced happy music, due to more detailed processing strategies elicited under positive compared to negative transient mood states. This hypothesis was based on studies showing different cognitive processing strategies used for positive and negative mood (Bless & Fiedler, 2006; Forgas, 2013; Jiménez-Ortega et al., 2012; Matovic et al., 2014), previous research showing that lyrics affect listeners differently depending on the music they are paired with (Ali & Peynircioğlu, 2006; Brattico et al., 2011), and research looking at the multitude of connections between music and language (Patel, 2008) and music and emotion (Juslin & Västfjäll, 2008).

Connections between affect and cognition

The finding that more error words were detected in the sad music condition is consistent with studies showing different processing strategies elicited with different moods, and helps to explain why lyrics appear to be processed differently depending on the valence of the music they are paired with (Ali & Peynircioğlu, 2006; Brattico et al., 2011). A growing body of research shows a strong neurological coupling of affect and cognition (Forgas, 2008), and there are a number of researchers who argue for the importance of studying affect and cognition as mutually influential domains. Duncan and Barrett (2007) suggest that affect is a form of cognition itself, and that affective and cognitive networks are connected via feedback loops. Davidson (2003) goes as far as to say that it is a sin of affective neuroscience to suggest that affect and cognition utilise separate neural pathways; while Storbeck and Clore (2007, 2008) suggest that affect may modulate cognition, and that trying to separate the two or determine cause and effect is futile. Recent work by Matovic et al. (2014) suggests that mood has an effect on the cognitive processing of language. Such research shows the influence affect has on cognition, and vice versa, and lends further weight to the hypothesis that mood can influence cognitive processing style, as shown in the current experiment.

The current study suggests that the valence of the music that lyrics are paired with can affect the way these lyrics are processed. To come to this conclusion, the stimuli were specifically designed to be as ecologically valid as possible, in that the mood inducing stimuli were the same stimuli as those being tested. We were particularly interested in how the music *itself* affected the online processing of lyrics, through the elicitation of transient mood states. Previous studies have shown that transient mood states affect subsequent processing of language (e.g., Federmeier et al., 2001; Jiménez-Ortega et al., 2012; Vissers et al., 2010). The main aim of this experiment therefore was to see whether this difference in processing could be seen in real time – with concurrently presented music and language. The studies by Ali and Peynircioğlu (2006) and Brattico et al. (2011) suggest that the brain processes lyrics differently depending on the valence of the music they are paired with. The current experiment is a first step in exploring why this might be.

Considerations and limitations

An important consideration in this design is whether the speed of the lyrics (related to the bpm) affected error detection. Since happy music is characterised by fast tempo and major key, and sad music by slow tempo and minor key (Juslin & Laukka, 2004), this potential confound could not be avoided while retaining ecological validity and strong distinctions between happy and sad stimuli. It is possible that happy songs resulted in lower error detection merely because the words were sung faster due to the faster tempo. To control for this, happy and sad songs both had an average of 55 words, and were all approximately one minute in length, with a music-only introduction of approximately 15 seconds. Maintaining a similar number of lyrics between conditions was chosen instead of changing the tempo of the pieces, as studies have shown tempo to be a major defining feature of the mood evoked by a song (Gomez & Danuser, 2007; Juslin & Laukka, 2004), and that when these cues are mixed, emotion induction is likewise altered (Hunter et al., 2010). Future research could avoid the tempo issue by having spoken words paired with differently valenced music. While this is not as ecologically valid, it might yield more experimental control.

The PANAS mood scale was used to assess mood at baseline, after happy, and after sad stimuli (Watson et al., 1988). Positive affect ratings were significantly higher after happy than after sad music, and negative affect ratings were significantly higher after sad than after happy music, showing that the intended moods had been induced. While the results did show significant effects of stimuli on mood, there appeared to be some floor effects on the negative scale. There were much higher ratings and variability within the positive affect ratings, suggesting (1) that positive mood was affected by the stimuli to a greater extent than negative mood (as seen in the greater variation between conditions), (2) that the participants in this sample had high positive affect to begin with, or (3) that the scale was not a good measure for negative transient mood states. Some researchers have suggested that emotions induced by music should not be rated with the same scales as emotions induced through other means, due to both the richness of musical emotions and potential differences between musically induced emotions and emotions from so-called "real-world" events (Vuoskoski & Eerola, 2011). This could also have been a factor as to why the negative affect scale did not appear very sensitive. Music-specific emotion scales (such as the Geneva Emotional Music Scale: Zentner, Grandjean, & Scherer, 2008) were not used because their suitability for music with lyrics has not been ascertained. A well-tested, general mood scale was therefore viewed as the most appropriate measure. Future research however should use a measure that is more sensitive to negative musical emotions in particular, especially when looking explicitly at happy and sad exemplars. The development of a measure of musical emotions which has been validated with lyrics is also advised.

Conclusion

The current experiment supports studies showing that lyrics are processed differently depending on the music they are paired with (Ali & Peynircioğlu, 2006; Brattico et al., 2011). It is further suggested that this is due to the use of different processing styles, in line with studies suggesting that cognitive processing is influenced by mood (Forgas, 2013; Matovik et al., 2014). Future research should expand the current findings by looking at more mood categories (e.g., angry, calm) to better understand the connections between lyrics, mood, and music; incorporate arousal into future research to better understand the complexities of the arousal-valence spectrum and how this relates to lyrics and music; and employ a more appropriate mood scale for musically induced transient mood states. The current findings have valuable implications for various fields, including music therapy, music and language research, as well as general music use and understanding. They also have implications for understanding the complex interactions between mood, lyrics and cognitive processing, and show the importance of mood in understanding connections between music and language.

Ethical approval

Ethical permission for this study was not needed, according to the guidelines stated by the University of Jyväskylä Ethical Committee.

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Appendix A

Name	Key	Words	BPM	Error?
HAPPY 1	D	61	132	Y
HAPPY 2	E	60	138	Y
HAPPY 3	G	60	144	N
HAPPY 4	B	49	152	Y
HAPPY 5	D	56	144	Y
HAPPY 6	C	59	144	N
HAPPY 7	G	54	132	N
HAPPY 8	D	58	138	Y
HAPPY 9	F	60	144	Y
HAPPY 10	A	62	138	N
HAPPY 11	A	47	144	N
HAPPY 12	B	55	138	N
HAPPY 13	E	55	160	Y
HAPPY 14	F	48	152	Y
HAPPY 15	A	46	120	N
HAPPY 16	C	43	138	N
HAPPY 17	G	56	152	Y
HAPPY 18	E	55	152	N
HAPPY 19	C	57	132	Y
HAPPY 20	F	62	132	N
AVG		**55.15**	**141.3**	
SAD 1	Dm	56	76	N
SAD 2	Em	59	84	N
SAD 3	Bm	56	84	Y

Appendix A. (Continued)

Name	Key	Words	BPM	Error?
SAD 4	C#m	58	84	N
SAD 5	F#m	47	84	N
SAD 6	Dm	47	80	Y
SAD 7	C#m	45	76	N
SAD 8	Dm	61	72	N
SAD 9	Am	62	84	Y
SAD 10	Gm	55	84	N
SAD 11	Fm	62	88	Y
SAD 12	Cm	64	80	Y
SAD 13	Em	60	80	N
SAD 14	Bm	54	84	Y
SAD 15	Am	46	88	Y
SAD 16	Gm	55	88	Y
SAD 17	Cm	55	88	N
SAD 18	Fm	51	80	Y
SAD 19	F#m	55	69	Y
SAD 20	Am	56	86	N
AVG		**55.25**	**81.95**	