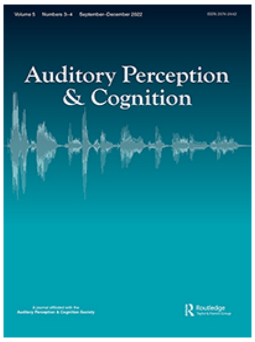

Auditory Perception & Cognition

Routledge
Taylor & Francis Group

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rpac20

Cross-modal Transfer of Valence or Arousal from Music to Word Targets in Affective Priming?

James Armitage & Tuomas Eerola

To cite this article: James Armitage & Tuomas Eerola (2022) Cross-modal Transfer of Valence or Arousal from Music to Word Targets in Affective Priming?, Auditory Perception & Cognition, 5:3-4, 192-210, DOI: 10.1080/25742442.2022.2087451

To link to this article: https://doi.org/10.1080/25742442.2022.2087451

Published online: 23 Jun 2022.

AUDITORY PERCEPTION & COGNITION
2022, VOL. 5, NOS. 3–4, 192–210
https://doi.org/10.1080/25742442.2022.2087451

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Cross-modal Transfer of Valence or Arousal from Music to Word Targets in Affective Priming?

James Armitage and Tuomas Eerola

Music Department, Durham University, Durham, UK

ABSTRACT
This registered report considers how emotion induced in an auditory modality (music) can influence affective evaluations of visual stimuli (words). Specifically, it seeks to determine which emotional dimension is transferred across modalities – valence or arousal – or whether the transferred dimension depends on the focus of attention (feature-specific attention allocation). Two experiments were carried out. The first was an affective priming paradigm that will allow for the orthogonal manipulation of valence and arousal in both the words and music, alongside a manipulation to direct participants' attention to either the valence or the arousal dimension. Secondly, a lexical decision task allowed cross-modal transfer of valence and arousal to be probed without the focus of participants' attention being manipulated. Congruence effects were present in the affective priming task – valence was transferred in both the valence and arousal tasks, whereas arousal was transferred in the arousal task only. Contrary to predictions, the lexical decision task did not exhibit any congruence effects.

ARTICLE HISTORY
Received 6 October 2020
Accepted 23 April 2021

KEYWORDS
Music & emotion; cross-modal; affective priming; reaction time

Introduction

The relationship between music and emotion is well established and has been the subject of much research activity in recent years (see, e.g., Geethanjali et al., 2018, for a review). Music and emotion studies have considered a wide range of questions around emotion induction, personality traits, classification, and emotion regulation. Importantly, musically induced emotions do not exist solely within the context of music. Music also has the ability to influence emotional judgments about stimuli in other domains – a property that is utilized for instance, in advertising and film music, or in compositional techniques such as word-painting or leitmotif. The present study seeks to probe more explicitly, via affective priming (Fazio et al., 1986), the nature of the transfer of emotions from music to other domains. In particular, it addresses the central question of what aspects of emotion can be transferred from music to influence judgments about stimuli in other dimensions.

CONTACT James Armitage james.e.armitage@durham.ac.uk Music Department, Durham University, Durham, UK

Affective Priming

The affective priming paradigm evaluates automatic responses to affective stimuli. Typically, two stimuli are presented in succession, and the second stimulus (the *target*) is evaluated according to some affective criterion. The response to the target is thought to be influenced by the affective context provided by the first stimulus (the *prime*). For instance, positive words may be classified more accurately (or quickly) when immediately preceded by a 'happy' sound than by a 'sad' sound; similarly, a negative word may be classified more accurately (or quickly) when preceded by a sad or angry sound than by a happy sound (see, for example, Scherer & Larsen, 2011). This phenomenon is known as a *congruency effect* or *priming effect*.

Priming studies have been used in music cognition for over 30 years, dating from Bharucha's series of seminal harmonic priming studies (for example, Bharucha & Stoeckig, 1986, 1987). Although the present study does not address the mechanisms by which affective priming takes place, a brief overview of the two mechanisms that have been proposed as explanations of priming is necessary to address the question of which of valence or arousal is transferred. The first proposal (Fazio et al., 1986) is that priming effects are the consequence of spreading activation in the semantic network: exposure to a positive (negative) prime stimulus activates related concepts in the semantic network and consequently a succeeding positive (negative) target stimulus can be evaluated more quickly as the concept is already partially activated. An alternative explanation is that Stroop-like interference inhibits responses when the prime and target stimuli are of opposing valence (the *incongruent* conditions) (see, e.g., Klauer, 1997).

Transfer of Basic Emotion or Valence-Arousal

Broadly speaking, there are two commonly used families of frameworks for studying emotion. These are the basic emotion models (for instance, Ekman, 1992) and the dimensional models, such as the circumplex (i.e., valence-arousal) model put forward by Russell (1980). Ekman identified six different human emotions, i.e., families of affective states: *happiness, anger, fear, disgust*, *sadness*, and *surprise*. Under this model, other emotions are considered to be combinations of these so-called basic emotions, so, for instance, jealousy can be considered a combination of anger, fear, and sadness.[1] In the circumplex model, emotions are considered in the two-dimensional valence-arousal space. Broadly speaking, the valence dimension provides information about an emotion's pleasantness; the arousal dimension provides information about the degree of activation or tension. The circumplex model has been the most frequently applied framework to study the emotional content of music (Eerola & Vuoskoski, 2012).

In addition to recent consideration of affect transfer described in terms of valence and/or arousal, there have been attempts to consider affective priming in terms of basic emotions (Boakes, 2010; Carroll & Young, 2005). Boakes compared the results for valence congruency with emotion congruency in three affective classification experiments and found a significantly greater facilitation effect for emotion congruence than valence congruence in two of the three studies (both using visual stimuli), with no significant difference in the third (lexical stimuli). However, most studies have used the valence-arousal framework, and it is possible to map basic emotions to the valence-arousal model. Furthermore, dimension-arousal priming studies that have involved emotion more specifically have focused on valence rather than arousal as the transferred dimension of emotion (e.g., Bakker & Martin, 2015; Costa, 2013; Steinbeis & Koelsch, 2011). One exception is Marin et al. (2012) who argue that arousal rather than valence is transferred in cross-modal priming, whereas Scherer and Larsen (2011) and Liu et al. (2018) argue that both valence and arousal are transferred but that valence makes a greater contribution to the priming effect than arousal. In general, however, there has been scant acknowledgment of the role of arousal in the music priming literature. Furthermore, dimension-arousal is well established as a model of music-induced emotion (Eerola & Vuoskoski, 2011; Ilie & Thompson, 2006). Although Liu et al. (2018) use basic emotions as labels for stimuli, their careful manipulations of timbre were mapped to responses in valence and arousal. Therefore, the valence-arousal model is favored in the present study.

Valence Transfer

Most music priming studies (Hermans et al., 2001; Sollberger et al., 2003; Steinbeis & Koelsch, 2011; Yuan et al., 2014) have focused on transfer of valence, which mirrors the picture in priming studies more broadly (for instance Fazio et al., 1986). Scherer and Larsen (2011) argue that both valence and arousal are transferred in affective priming, but that the effect of valence is significantly greater than that of arousal. The main theoretical basis for valence transfer is provided by the spreading activation models (Fazio et al., 1986; Hermans et al., 2001; Sollberger et al., 2003). In essence, information is classified simply as positive versus negative (or happy versus sad, etc.) and the corresponding memory nodes are activated; other concepts linked to these nodes are more accessible and consequently response times to congruent targets are quicker than to incongruent targets. Indeed, given the relatively large body of empirical work framed in terms of valence transfer, the congruency effect of valence does seem to be well established. Furthermore, the theoretical models based around Stroop-like conflicts also seem to lend weight to valence transfer. However, as will be discussed below, considering transfer of emotion more fully potentially accounts for a greater proportion of the variance in priming effects than considering valence alone.

Arousal Transfer

The main challenge, in music priming studies at least, to the notion of valence transfer is provided by Marin et al. (2012), who argue in favor of arousal transfer. Outside of music studies, Q. Zhang et al. (2012) and Hinojosa et al. (2009) argue in favor of arousal and the interaction of arousal and congruence, respectively. Marin et al. discuss arousal transfer in the context of excitation transfer theory (e.g., Zillmann, 1983). However, Zillman's theory suggests that arousal produced by an initial stimulus is slow to dissipate – there is consensus within the priming literature that the window for affective priming effects is very short, with effects decaying after about 250 ms. Whilst Marin et al.'s protocol does use a short stimulus onset asynchrony, Zillman's theory seems to lend itself better to explaining phenomena such as aggression (Zillmann, Katcher, Milavsky et al., 1972a) and response to advertising (Mattes & Cantor, 1982) rather than affective priming, owing to the longer timescale that Zillman's effect works on. However, most authors (Scherer &

Larsen, 2011; Sollberger et al., 2003) base their arguments on transfer of valence as discussed above. Interestingly, Scherer and Larsen do find a small main effect of arousal but choose to frame their argument in favor of valence; it is not clear whether or not they considered or tested for an interaction. Storbeck and Clore (2008) review the available literature on the arousal dimension of affect as information and discuss in detail the role of arousal in evaluation. Specifically, they argue that arousal tells us the urgency of the information.

A construct that has the potential to explain priming effects in terms of arousal is vigilance. Scherer and Larsen (2011) suggest this tentatively but rely on more traditional explanations of priming in their discussion. Accepting vigilance as an explanation for priming would seem to suggest different responses to positive and negatively valenced stimuli. However, if arousal is considered as the main vehicle for priming, then the seemingly paradoxical facilitation effect in the positive–positive condition is resolved: high arousal is interpreted as threat in the first instance, irrespective of the valence, therefore the attentional spotlight narrows to look for other high arousal (interpreted as threatening) stimuli thus accounting the facilitation effects in both positive and negative congruent conditions. This explanation would be particularly suitable for the musical priming studies cited, given the relative simplicity of the auditory stimuli (usually major vs minor or consonant vs dissonant chords): positive chords convey excitement arousal and minor chords convey tension arousal (Lahdelma & Eerola, 2016). A model that gave primacy to the role of arousal would also potentially explain the inconsistency with research that suggests that negative affect inhibits cognitive performance.

The Relationship between Valence and Arousal

Zhang et al. (2012) argue in favor of an interaction of valence and arousal in affective priming. Hinojosa et al. (2009) found no significant behavioral evidence in favor of a role for arousal in affective priming, but, when they considered ERP activity, they did find significant main effect of arousal congruency and an arousal congruency × target type interaction in the late positive component. It is therefore feasible that the interaction of valence and arousal is the key aspect in cross-modal affective priming, especially in light of Hinojosa et al.'s ERP results. Indeed, valence-arousal models of emotion could be consistent with the empirical basic emotion results discussed earlier. Curiously, Costa (2013) found that congruence effects were present when participants were asked to classify target words as positive or negative following valenced chords, but that prime valence did not lead to congruence effects using picture targets. He did, however, find significant facilitation in congruent register-affect conditions using faces as targets. He makes a tentative argument that arousal is transferred more effectively by higher register chords. Further support for the arousal transfer model is found outside of music cognition by Zhang et al., who similarly argue for a role for the interaction of valence and arousal in affective priming. However, in a purely lexical affective priming task, Hinojosa et al. (2009) found no significant main effect of arousal but did find a significant arousal × congruence interaction. However, Storbeck and Clore (2008) review evidence that suggests that arousal narrows attentional focus, which would be consistent with Marin et al.'s account. Liu et al. (2018) matched prime and target stimuli for both valence and arousal. However, the focus of their research was eliciting affective priming effects via manipulations of acoustic properties rather than the dimensions of emotions. Nevertheless, they found significant priming effects in both behavioral and ERP results. Scherer and Larsen (2011) noted that their setup did not discriminate fully between valence and arousal transfer and suggested that further research be carried out to probe this issue more systematically. In particular, they suggested that, for their stimulus set at least, negative stimuli were notably higher in arousal than positive stimuli. Consequently, it was not possible to argue conclusively that one dimension had a greater effect than the other.

Feature-Specific Attention Allocation

Rather than a simple transfer of valence or arousal, a strong alternative model of transfer is feature-specific attention allocation (Spruyt et al., 2009, 2012). In simple terms, this model predicts that the transferred dimension will vary according to which dimension is attended to: if participants are making arousal evaluations, arousal will be transferred; if participants are making valence evaluations, then valence will be the transferred quantity. However, whilst this has been applied where the congruence categories under investigation have been affective versus not affective, it is as yet untested when the congruence categories have been two orthogonal dimensions of affect. Although Spruyt and colleagues present a strong case for feature-specific attention, Becker, Klauer, and Spruyt (2016), however, attempted, in an adversarial collaboration, to replicate Spruyt's findings – that for priming effects to be detected, attention must be drawn to the relevant dimension in the instructions – and failed to find significant priming effects, albeit using a pronunciation rather than an evaluative task. Becker et al. (2016) suggest that the original authors' results hinged on strong semantic relationships between the prime–target pairs. Therefore, as well as having significance in music emotion research, the present study will also contribute to the debate around the role of attention in affective priming.

Clearly, there is a strong consensus that both of the congruent conditions (positive prime – positive target, negative prime – negative target) facilitate reaction speed. Most studies have used relatively simple primes, e.g., major vs. minor or consonant vs. dissonant chords. *Prima facie*, this seems to support the idea of valence transfer. However, it still leaves scope to consider the question of valence vs arousal transfer if the nature of arousal is considered more closely. In particular, whilst Marin et al. (2012) considered arousal as one orthogonal dimension of affect, there is evidence to suggest that arousal can be further subdivided into excitement and tension arousal (Ilie & Thompson, 2006). Lahdelma and Eerola (2016) used this framework to consider emotion arousal in single chords and found empirical evidence to suggest that individual chords convey both valence and arousal, but that major chords convey excitement arousal, whereas minor and more dissonant chords are higher in tension arousal. Therefore, given the relative lack of consideration of the arousal dimension, many of the current studies do not intrinsically favor either an arousal or valence argument. Further studies are necessary to unravel the precise nature of the transfer.

There is strong agreement among authors that musical affective priming results in significant congruency effects: i.e., a positive stimulus facilitates categorization of a positive target, and a negative stimulus facilitates categorization of a negative stimulus. However, almost all music priming studies to date manipulate valence rather than arousal, whereas Marin et al. (2012) propose arousal as being the dominant dimension transferred in priming, albeit in a rating rather than a response time task. The present study uses the feature-specific attention allocation (FSAA) framework proposed by Spruyt et al. (2009); (2012) to address this question.

The Present Study

The present study considers cross-modal transfer of both valence and arousal in two priming tasks. In Experiment 1, participants will complete a primed lexical decision task. In Experiment 2, participants will complete a word classification task, in which participants will categorize target words according to either their arousal or their valence properties. In both tasks, we will systematically vary both the valence and arousal properties of the prime and target stimuli. In this respect, the design differs from existing studies, which have for the most part used a binary division of auditory primes (positive/negative; major minor; resolved/unresolved). It will use musical primes that draw on a wider range of affects than has previously been the case. Despite the differences from previous studies, this experiment will incorporate aspects of replication of Scherer and Larsen (2011) using musical rather than non-musical primes. It will additionally consider more specific correspondences in both arousal and valence with a view to evaluating the competing models proposed by Scherer and Larsen (2011), Marin et al. (2012), and Spruyt et al. (2009). With regard to feature-specific attention allocation, existing studies have considered evaluation of affect versus evaluation of a non-affective category, where the affective classification has focused on valence only; this study will have separate valence and arousal classification tasks. To the authors' knowledge this is the first study to consider priming of valence and arousal as orthogonal dimensions exploiting feature-specific attention allocation.

Experiment 1a and 1b: Valence and Arousal Priming

Participants

Brysbaert and Stevens (2018) suggest a requirement of 1600 readings per condition to achieve adequate power in mixed effect designs. Thus, with 128 items (see procedure below) divided into four conditions, i.e., 32 items per condition, 50 participants were needed for the valence task, and 50 for the arousal task. Sixty-five participants completed the arousal priming task and 58 completed the valence priming task. The item-wise deletion rate for the arousal task was higher than in the valence task, resulting in a slightly higher number of participants than expected in order to satisfy Brysbaert and Stevens (2018)'s power criterion of 1600 readings per condition. Participants were recruited via Prolific and were remunerated at an hourly rate of $11. All participants reported normal or corrected to normal vision and hearing and were native speakers of English. Additionally, participants were right-handed (Hardie & Wright, 2014). Informed consent was given via an online check box, and the study was approved by the Ethics Committee of the host institution (Music Department, Durham University).

Materials

Thirty-two musical clips were selected from the list of excerpts used for musical mood induction compiled by Vastfjall (2001) and Eerola and Vuoskoski (2011). The clips were approximately 11 second in duration and represented the Western classical canon and film music genres. To establish which clips would be viable as primes for the present study, the clips were rated by a volunteer sample (n = 42, mean age = 37). The clips were rated on a scale of 1 to 7 for valence and arousal. The 16 clips (two per condition) that most clearly represented the four conditions, *Positive-High, Positive-Low, Negative-High, Negative-Low* were chosen as stimuli for the main experiment and trimmed to roughly 1000 ms for use as primes (see Table 1).

In common with Scherer and Larsen (2011), the auditory stimuli will each be roughly 1000 ms in duration (with minor deviation allowed to preserve the musical integrity of the clips) and will consist of musical extracts drawn from 16 different pieces of music – four each to represent positive valence-low arousal, positive valence-high arousal, negative valence-low arousal, negative valence-high arousal. Table 1 lists the musical excerpts, which are also available at https://osf.io/qau7n/?viewonly = 52349d998411420ab0d3edc5084ef617. The duration of 1000 ms is considered to provide the optimal trade-off in being sufficiently long to induce an affective response whilst avoiding decay in the priming effect (Bigand et al., 2005; Hermans et al., 2001). Musical excerpts rather than individual chords or short progressions have been chosen to mirror the ecologically valid approach taken by Scherer and Larsen (2011).

The 16 target words (Table 2), 2 for each condition, were drawn from Warriner et al. (2013) and were matched for length.

In each item in the priming task, the prime and the target stimulus are either matched (congruent on both dimensions), partially matched (congruent on one of the arousal or valence), or mismatched (incongruent on both dimensions).

Table 1. Music primes for affective evaluation task by valence-arousal (mean valence and arousal ratings given in brackets[a]).

Positive-high	Positive-low
Sousa – Stars and Stripes Forever (7.95, 8.02)	Shine (Tr 10) (5.88, 3.21)
Batman (Tr 18) (7.65, 7.62)	Pride & Prejudice (Tr 1) (6.18, 2.30)
Man of Galilee, CD 1 (Tr 2) (7.25, 7.25)	Holst – The planets: Venus (5.97, 3.64)
Tim Weisberg – The Good Life (7.71, 7.13)	Dances with Wolves (Tr 4) (6.42, 2.88)
Negative-high	**Negative-low**
Holst – The Planets: Mars (3.68, 8.29)	Albinoni – Adagio (3.64, 3.64)
Cape Fear (1) (2.94, 6.98)	Grieg – Death of Aase (4.17, 3.06)
The Rainmaker (Tr 7) (3.24, 8.18)	Schubert – Quartet, D810., 2nd Mvt (3.15, 2.91)
Lethal Weapon 3 (Tr 8) (3.03, 7.93)	English Patient (18) (3.59, 3.37)

[a]Valence-arousal ratings were collected on a scale of 1–7 but here are normalized to 1–9 to correspond to ratings in Warriner, Kuperman, and Brysbaert presented in Table 2.

Table 2. Target words for affective evaluative tasks grouped by valence-arousal (Valence-Arousal ratings given in brackets).

Positive-high	Positive-low	Negative-high	Negative-low
Climax (7.5, 6.8)	Gentle (7.4,3.2)	Rabid (3.0, 6.6)	Saggy (2.6, 3.0)
Lively (7.1,6.1)	Rest (7.9,2.2)	Hijack (1.8,6.1)	Flaccid (3.55,3.14)
Excite (7.8,6.6)	Comfy(7.2,2.9)	Arrest (2.3,6.7)	Dismal (2.6,3.3)
Snazzy (6.5,5.4)	Relax (7.8,2.4)	Fatal (2,6.8)	Morgue (1.8,3.5)

Alongside the basic demographic measures, participants completed the one-item version of the Ollen Musical Sophistication Index (OMSI-1, Ollen, 2006; Zhang & Schubert, 2019). The affective priming task was coded in PsyToolkit (Stoet, 2010, 2017) to allow for the collection of robust reaction time data online via a local javascript (see Barnhoorn et al., 2015; De Leeuw & Motz, 2016, for discussion of online response time collection). See Armitage and Eerola (2020) for a direct comparison of laboratory and online data collection of reaction time using music stimuli as well as the discussion of different samples.

Procedure

Following the procedure set out by Scherer and Larsen (2011), participants were initially informed that they were taking part in an experiment about the influence of music on reading. The whole experiment lasted around 15 min. 50% of the participants completed the valence evaluation task; 50% completed the arousal evaluation task. Each task consists of a ten-item practice block followed by two experimental blocks of 64 items each, with a short pause in between. During the practice block, participants received feedback on whether their response is correct or incorrect; no indication as to whether or not responses are correct was given during the experimental block. Within the blocks, the items were be presented in a random order.

Valence Evaluation Task

Participants were be presented with 1000 ms of the auditory prime. During the auditory prime, the screen contained a fixation cross for 450 ms; after 450 ms, the target word was be displayed for 2000 ms, the window during which participants could respond. Participants were instructed to press “z” if the word had negative associations and “m” if the word had positive associations.

Arousal Evaluation Task

The procedure for the arousal evaluation task was be identical to that for the valence evaluation task, with the key difference that participants were instructed to press the “z” key if the target word is low in arousal and the “m” key if the target word is high in arousal. In addition, as the terms “high arousal” and “low arousal” may not be as intuitively clear to participants, participants saw an additional page of instructions explaining this in more detail prior to the experiment commencing: ”Emotions can be classed as high arousal or low arousal. High arousal emotions are associated with energy, tension or activation. Examples of high arousal adjectives are awake, alert, restless. Low arousal emotions are associated with stillness or a lack of energy or activation, such as sleepy, tired, drowsy or serene. In this task you will classify words as high or low in arousal." (See Appendix for instructions given during the experimental task).

Statistical Analysis

All analyses were carried out in R (R Core Team, 2021) at $\alpha = .05$. Individual participants whose accuracy rate fell below 75% were excluded from the analysis. Timeouts (i.e., responses to individual items that exceed 2000 ms) were excluded. For RT analysis, incorrect answers were be excluded. Each participant's RT data will be fitted to an ExGaussian distribution (Ratcliff, 1993). Individual RTs that are below 250 ms or greater than the 95th percentile of the ExGaussian distribution will be deleted.

RT distributions were analyzed using a generalized linear mixed model (GLMM) fitted using a gamma function. The fixed effects were task (valence vs. arousal) and congruence (congruent vs. incongruent) and participants as a random factor, testing whether there is any difference in reaction times between congruent and incongruent conditions. Crucially, we considered the effect of interaction *Task* × *Valence Congruence* × *Arousal Congruence* on reaction time (see hypotheses below) via a 2 × 2 × 2 type III Anova. Planned contrasts with Bonferroni corrections for multiple comparisons were used to compare RTs in the different congruency conditions.

Experiment 2: Lexical Decision Task

The priming tasks outlined above tested which of valence or arousal primes responses to target words when participants' attention is focused on a specific dimension by the task instructions. However, the design of Experiment 1 did not allow us to determine the roles of valence and arousal in priming responses to target words in a more naturalistic context. Consequently, we include a second experiment in which the transfer of valence and/or arousal from primes to targets is considered without participants' attention being directed to either dimension.

Participants

Using Brysbaert and Stevens (2018) figure of 1600 readings per condition, and 64 'real word' trials per participant split into four conditions, i.e., 16 trials per condition (see Design and Procedure, below), a minimum of 100 participants were needed to complete the study.

Materials and Stimuli

The primes were identical to those used in Experiment 1. However, the target set included both 'real' target words and nonsense 'non-words'. The real words are identical to those used in Experiment 1. The non-words were generated using an online nonsense word generator and are four, five, or six letters long and consist of one or two syllables; the stimuli are available at https://osf.io/qau7n/?viewonly = 52349d998411420ab0d3ed-c5084ef617. The music primes are also identical to those used in Experiment 1.

Design and Procedure

The outline procedure was similar to the valence and arousal classification tasks. The key decision, however, was whether a target forms a word or a non-word. Participants were presented with 1000 ms of the auditory prime. During the auditory prime, the screen contained a fixation cross for 450 ms; after 450 ms, the target word was displayed for 2000 ms, the window during which participants could respond. Participants were instructed to press "z" in response to a non-word an "m" in response to a real word.

Participants initially completed a 10-item practice block, during which they received feedback to indicate whether or not their response was correct after each item. This was followed by two experimental blocks of 64 items each, divided between 32 real words and 32 non-words. As with the valence and arousal tasks, the task was counterbalanced between participants to ensure that all prime-target pairs are represented equally. During the experimental block, no feedback was given as to whether or not the response to each item is correct.

Statistical Analysis

Responses to non-words were deleted prior to analysis. The analysis broadly followed the strategy employed in Experiment 1. Again, the critical interaction under consideration was *Valence Congruence* × *Arousal Congruence*. Planned contrast analysis with Bonferroni corrections for multiple comparisons is tested for differences in RTs in the following valence-arousal congruency conditions: *Congruent–Congruent, Congruent-Incongruent, Incongruent-Congruent, Incongruent-Congruent.*

Hypotheses/Expected Results

All hypotheses apply to the affective priming task; only 1), 2) and 4) apply to the Lexical Decision Task.

(1) Valence transfer: reaction times will be faster in the prime, and target stimuli have congruent valences. Reaction time will be independent of any congruence in the arousal dimension.
(2) Arousal transfer: reaction times will be faster in the prime, and target stimuli are congruent in the arousal dimension. Reaction time will be independent of any congruence in the valence dimension.
(3) Feature-Specific Attention Allocation hypothesis: in line with Spruyt et al. (2009), (2012), the interactions of *Task* × *Valence Congruence* and *Task* × *Arousal Congruence* will be significant and indicate that congruence effects will depend on task: responses to the valence task will exhibit congruency effects in the valence dimension but not the arousal dimension; responses to the arousal task will exhibit congruency effects in the arousal dimension but not the valence dimension.
(4) Words that are congruent in both the valence and arousal dimensions will be classified as words more quickly than those which are congruent in one dimension only, which in turn will be classified more quickly than those which are not congruent in either dimension. In the case of Experiment 1, we predict more specifically that when there is congruence in one dimension only, RTs will be quicker when that dimension corresponds to the attended dimension in the task.

Results

Experiment 1

We carried out the statistical analyses in line with the registered report plan. The critical three-way interaction *Task* × *Valence Congruence* × *Arousal Congruence* proved significant, ($\chi^2(1) = 10.23$, $p = .0013$). The main effects and two-way interactions were assumed to be subsumed into the three-way interaction. The registered planned contrasts were carried out, revealing that in the valence priming task, there was a significant valence priming effect – i.e., RTs in incongruent conditions (mean RT = 560 ms, SD = 101 ms) were significantly slower than in congruent conditions (mean RT = 553 ms, SD = 102 ms), $z(\infty) = 3.700, p = .0001$, whereas no arousal priming effect was present, $z(\infty) = 1.24, p = .1105$: mean (SD) RTs in incongruent and congruent conditions were 558 (101) ms and 555 (102) ms, respectively. In the arousal priming task, the predicted arousal priming effect was present, $z(\infty) = 8.903, p < .0001$, with RTs in the incongruent arousal condition (mean RT = 595 ms, SD = 133 ms) being slower on average than in the congruent condition (mean RT = 581 ms, SD = 136 ms). In addition, the arousal priming task also revealed a significant valence priming effect – i.e., RTs for arousal classification were significantly shorter when the prime and target shared the same valence compared to when they did not share the same valence.

To test Hypothesis 4, we grouped RTs by task and by four levels of congruence: no congruence, congruence in the attended dimension, congruence in the unattended dimension, and congruence in both dimensions. We fitted a GLMM that was in turn submitted to an omnibus type III Anova. There was a significant effect of congruence, $\chi^2(3) = 17.2$, $p < .001$. Planned contrasts revealed that there was no difference in reaction times between items where the congruence was in both dimensions and in the attended dimension only nor in the conditions where the congruence was in the attended dimension compared to the unattended dimension. However, RTs were significantly shorter when the congruence was in both dimensions compared to the unattended dimension, $z = 3.3$, $p = .002$ (mean RTs, 553 vs. 557 ms) and when the congruence was in the attended dimension compared to no congruence, $z = 3.5$, $p = .001$ (mean RTs 553 vs. 563 ms). There was no significant difference in RTs between items where there was congruence in the unattended dimension compared to items where there was no congruence.

Exploratory Analysis

To explore the presence of the valence priming in the arousal task further, we carried out an additional contrast analysis that was not included in the original registered report plan. We compared the valence congruency effect at the two levels of arousal congruency. Considering only those trials where the arousal levels of the prime and target were incongruent, there was no evidence of a valence congruency effect, $z(\infty) = 0.85$, $p = 0.3979$. However, when we considered the trials were the arousal levels of the prime and target were the same, there was a significant congruency effect – i.e., target words were evaluated more quickly when they shared the same valence as the music primes than when they did not, $z(\infty) = 3.00, p = .0027$.

Additionally (and with thanks to the anonymous reviewers for suggesting this analysis), we considered accuracy rate (AR). ARs were fitted to a GLMM, which was in turn subjected to a 2 (Task) × 2 (Arousal Congruence) × 2 (Valence Congruence)

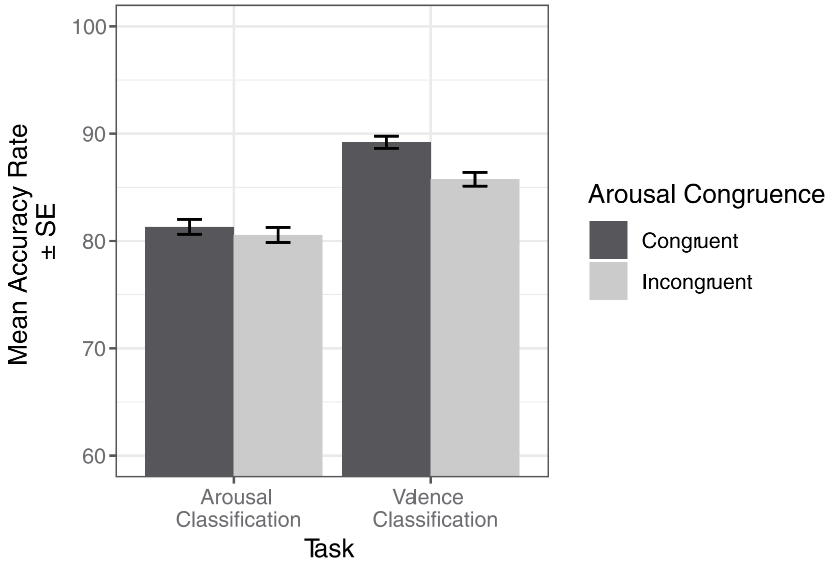

Figure 1.. Accuracy rates for valence and arousal classification tasks by arousal congruence.

type III Anova. There was a significant two-way interaction of Task with Arousal Congruence, $\chi^2(1) = 7.95$, $p = .005$. Counter to expectations, post hoc t-testing revealed that there was a significant difference in AR in the valence classification task at different levels of arousal congruence: in the congruent condition, the mean AR was 89.2% (SE = 0.58); in the incongruent condition, the mean AR was 85.7% (SE = 0.63), $t(115) = 4.62$, $p < .001$. All other two- and three-way interactions were non-significant as were the main effects. The AR congruency effect is shown in Figure 1.

Experiment 2: Lexical Decision Task

113 participants, who had not taken part in Experiment 1, completed the Lexical Decision Task; 5 failed to achieve the required accuracy rate, and so their data were removed prior to analysis. Following deletion of outliers (see Statistical Analysis, above), this left over 1720 readings per condition, meeting Brysbaert and Stevens (2018)'s criterion for adequate power. The data were subject to a 2 × 2 type III Anova. Contrary to the hypotheses above, no main effects of *Arousal Congruence* ($\chi^2(1) = 0.6196$, $p = .43$), *Valence Congruence* ($\chi^2(1) = 0.3705$, $p = .54$) were present; the interaction *Arousal Congruence* × *Valence Congruence* also proved non-significant, $\chi^2(1) = 0.047$, $p = 0.8382$.

Exploratory Analyses

Accuracy rates in the valence and arousal congruency conditions are shown in Table 3. ARs were subjected to a 2 (Arousal Congruence) × 2 (Valence Congruence) Type III ANOVA. Both the main effects and their interaction proved non-significant.

Table 3. Mean (standard deviation) accuracy rates for valence and arousal congruency conditions.

Arousal congruence	Valence congruence	Accuracy rate (SD)
Congruent	Congruent	88.5 (7.8)
Congruent	Incongruent	87.7 (7.9)
Incongruent	Congruent	88.0 (8.7)
Incongruent	Incongruent	88.0 (8.3)

Discussion

Experiment 1 provided partial support for Hypotheses 1 and 3 – i.e., valence priming was evident in both the valence and arousal priming tasks. Arousal priming was present only in the arousal priming task. This perhaps suggests that the semantic networks have an automatic tendency to activate valence-related information, whereas – in this context – the arousal information is activated only when it is a requirement of the task. This asymmetric effect of valence and arousal congruency (i.e., valence congruency influence RTs on the arousal classification task but not vice versa) is perhaps analogous to (although in a very different domain from) the asymmetric effects of pitch on temporal position – variations of pitch influence judgments of temporal position, whereas variations in temporal position do not influence judgments about pitch (Prince et al., 2009). However, the non-registered AR analysis suggests that the arousal information is activated but influences AR rather than RT. It is not clear why there should be a difference in how the arousal and valence information should influence responses. Future research should utilize statistical methods that integrate accuracy rate and reaction time such as diffusion-drift modeling (Ratcliff, 1978). The non-registered contrast analysis perhaps points to the alternative explanation that, in the arousal task, increasing the degree of alignment in the affective information associated with the target in the prime causes an increase in the degree of facilitation. However, this effect is not apparent in the valence priming task.

There was partial support for Hypothesis 4: congruence in the attended dimension led to shorter RTs than congruence in the unattended dimension or no congruence. Interestingly, there was no RT advantage for instances where there was congruence in both dimensions compared to the attended dimension only. Again, this seems to lend weight to the argument that feature-specific attention allocation is an important factor in whether priming effects are present.

The absence of any of the hypothesized congruency effects in the Lexical Decision Task is surprising. To the authors' knowledge, this is the first time the difference between semantic and affective priming has been demonstrated in an auditory (and more specifically musical) context. We tentatively suggest that the absence of priming in the lexical decision task provides support for the Feature Specific Attention Allocation model (Spruyt et al., 2012) in that priming is only present in the tasks where the congruent dimension is referred to explicitly in the task. Alternatively, primed lexical decision tasks have been shown to be influenced by the associative as well as the semantic relatedness between the prime and target (e.g., Can˜s, 1990; Perea & Rosa, 2002). It may be the case that there was an insufficiently clear associative relationship between the music primes and the target words that results in priming effects. However, it is possible that some aspects of the procedure could influence the results (e.g., the 450 ms SOA that has proved effective in the affective priming task could be sub-optimal in the lexical decision task). Interestingly, this task was intended to give a sense of the influence of the affective content of music on word recognition without the influence of instructions that gave primacy to one dimension or another, i.e., an attempt to capture something more akin to a natural mode of listening. Therefore, it seems likely that a different paradigm may be necessary to truly capture the influence of emotional music on, for instance, the interpretation of lyrics.

The majority of evaluative priming research to date has focused on valence priming – it is possible that applying the same binary classification principle to arousal priming is less effective. It should be noted that Hinojosa et al. (2009) argued that the interaction of arousal and valence plays an important role in affective priming.

Future research should consider whether the valence and arousal priming effects are unique to music primes or whether the effects present in this study are independent of modality. Additionally, the question of whether basic emotion provides a better framework for priming research should also be considered.

Note

1. Ekman has since proposed an expanded list of basic emotions; other authors have proposed alternative lists, e.g., Izard et al. (1993)

Data Availability

The musical stimuli and PsyToolkit script are available at https://osf.io/hfbuk. Additionally, a draft of the valence priming task is available at https://www.psytoolkit.org/c/3.2.0/survey?s=CRsR9, the arousal task at https://www.psytoolkit.org/c/3.3.0/survey?s=Jngku and the lexical decision task at https://www.psytoolkit.org/c/3.3.0/survey?s=DazkM Raw.dat files, munged data in.csv format, R scripts, and additional figures are available via the same repository.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Faculty of Arts and Humanties Postgraduate Research Fund, Durham University (GB).

ORCID

James Armitage http://orcid.org/0000-0001-9802-7479
Tuomas Eerola http://orcid.org/0000-0002-2896-929X

References

Armitage, J., & Eerola, T. (2020). Reaction time data in music cognition: Comparison of pilot data from lab, crowdsourced, and convenience web samples. *Frontiers in Psychology*, *10*, 2883. https://doi.org/10.3389/fpsyg.2019.02883

Bakker, D. R., & Martin, F. H. (2015). Musical chords and emotion: Major and minor triads are processed for emotion. *Cognitive, Affective & Behavioral Neuroscience*, *15*(1), 15–31. https://doi.org/10.3758/s13415-014-0309-4

Barnhoorn, J. S., Haasnoot, E., Bocanegra, B. R., & van Steenbergen, H. (2015). Qrtengine: An easy solution for running online reaction time experiments using qualtrics. *Behavior Research Methods*, *47*(4), 918–929. https://doi.org/10.3758/s13428-014-0530-7

Bharucha, J. J., & Stoeckig, K. (1986). Reaction time and musical expectancy: Priming of chords. *Journal of Experimental Psychology. Human Perception and Performance*, *12*(4), 403. https://doi.org/10.1037//0096-1523.12.4.403

Bharucha, J. J., & Stoeckig, K. (1987). Priming of chords: Spreading activation or overlapping frequency spectra? *Perception & Psychophysics*, *41*(6), 519–524. https://doi.org/10.3758/BF03210486

Bigand, E., Filipic, S., & Lalitte, P. (2005). The time course of emotional responses to music. *Annals of the New York Academy of Sciences*, *1060*(1), 429–437. https://doi.org/10.1196/annals.1360.036

Boakes, J. A. (2010). *The role of specific emotions in affective priming effects*. University of Western Australia.

Brysbaert, M., & Stevens, M. (2018). Power analysis and effect size in mixed effects models: A tutorial. *Journal of Cognition*, *1*(1 1–20). https://doi.org/10.5334/joc.10

Can˜s, J. J. (1990). Associative strength effects in the lexical decision task. *The Quarterly Journal of Experimental Psychology*, *42*(1), 121–145. https://doi.org/10.1080/14640749008401211

Carroll, N. C., & Young, A. W. (2005). Priming of emotion recognition. *The Quarterly Journal of Experimental Psychology Section A*, *58*(7), 1173–1197. https://doi.org/10.1080/02724980443000539

Costa, M. (2013). Effects of mode, consonance, and register in visual and word-evaluation affective priming experiments. *Psychology of Music*, *41*(6), 713–728. https://doi.org/10.1177/0305735612446536

de Leeuw, J. R., & Motz, B. A. (2016). Psychophysics in a web browser? Comparing response times collected with javascript and psychophysics toolbox in a visual search task. *Behavior Research Methods*, *48*(1), 1–12. https://doi.org/10.3758/s13428-015-0567-2

Eerola, T., & Vuoskoski, J. K. (2011). A comparison of the discrete and dimensional models of emotion in music. *Psychology of Music*, *39* (1), 18–49. http://journals.sagepub.com/doi/10.1177/0305735610362821.

Eerola, T., & Vuoskoski, J. K. (2012). A review of music and emotion studies: Approaches, emotion models and stimuli. *Music Perception*, *30*(3), 307–340. https://doi.org/10.1525/mp.2012.30.3.307

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, *6*(3–4), 169–200. https://doi.org/10.1080/02699939208411068

Fazio, R. H., Sanbonmatsu, D. M., Powell, M. C., & Kardes, F. R. (1986). On the automatic activation of attitudes. *Journal of Personality and Social Psychology*, *50*(2), 229. https://doi.org/10.1037/0022-3514.50.2.229

Geethanjali, B., Adalarasu, K., & Jagannath, M. (2018). Music induced emotion and music processing in the brain – A review. *Journal of Clinical & Diagnostic Research*, *12*(1) VE01. doi:10.7860/JCDR/2018/30384.11060.

Hardie, S. M., & Wright, L. (2014). Differences between left-and right-handers in approach/avoidance motivation: Influence of consistency of handedness measures. *Frontiers in Psychology*, *5*, 134. https://doi.org/10.3389/fpsyg.2014.00134

Hermans, D., De Houwer, J., & Eelen, P. (2001). A time course analysis of the affective priming effect. *Cognition & Emotion*, *15*(2), 143–165. https://doi.org/10.1080/02699930125768

Hinojosa, J. A., Carreti´e, L., M´endez-B´ertolo, C., M´ıguez, A., & Pozo, M. A. (2009). Arousal contributions to affective priming: Electrophysiological correlates. *Emotion*, *9*(2), 164. https://doi.org/10.1037/a0014680

Ilie, G., & Thompson, W. F. (2006). A comparison of acoustic cues in music and speech for three dimensions of affect. *Music Perception: An Interdisciplinary Journal*, *23*(4), 319–330. https://doi.org/10.1525/mp.2006.23.4.319

Izard, C. E., Libero, D. Z., Putnam, P., & Haynes, O. M. (1993). Stability of emotion experiences and their relations to traits of personality. *Journal of Personality and Social Psychology*, *64*(5), 847. https://doi.org/10.1037/0022-3514.64.5.847
Klauer, K. C. (1997). Affective priming. *European Review of Social Psychology*, *8*(1), 67–103. https://doi.org/10.1080/14792779643000083
Klauer K Christoph, Becker M and Spruyt A. (2016). Evaluative Priming in the Pronunciation Task. Experimental Psychology, 63(1), 70–78. 10.1027/1618-3169/a000286
Lahdelma, I., & Eerola, T. (2016). Single chords convey distinct emotional qualities to both naive and expert listeners. *Psychology of Music*, *44*(1), 37–54. https://doi.org/10.1177/0305735614552006
Liu, X., Xu, Y., Alter, K., & Tuomainen, J. (2018). Emotional connotations of musical instrument timbre in comparison with emotional speech prosody: Evidence from acoustics and event-related potentials. *Frontiers in Psychology*, *9* (737). https://doi.org/10.3389/fpsyg.2018.00737 .
Marin, M. M., Gingras, B., & Bhattacharya, J. (2012). Crossmodal transfer of arousal, but not pleasantness, from the musical to the visual domain. *Emotion (Washington, D.C.)*, *12* (3), 618–631. http://www.ncbi.nlm.nih.gov/pubmed/21859191.
Mattes, J., & Cantor, J. (1982). Enhancing responses to television advertisements via the transfer of residual arousal from prior programming. *Journal of Broadcasting & Electronic Media*, *26*(2), 553–566. https://doi.org/10.1080/08838158209364024
Ollen, J. E. (2006). *A criterion-related validity test of selected indicators of musical sophistication using expert ratings* (Unpublished doctoral dissertation). The Ohio State University.
Perea, M., & Rosa, E. (2002). The effects of associative and semantic priming in the lexical decision task. *Psychological Research*, *66*(3), 180–194. https://doi.org/10.1007/s00426-002-0086-5
Prince, J. B., Thompson, W. F., & Schmuckler, M. A. (2009). Pitch and time, tonality and meter: How do musical dimensions combine? *Journal of Experimental Psychology. Human Perception and Performance*, *35*(5), 1598. https://doi.org/10.1037/a0016456
R Core Team. (2021). R: A language and environment for statistical ## computing. Vienna: R Foundation for Statistical Computing. https://www.R-project.org/.
Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review*, *85*(2), 59. https://doi.org/10.1037/0033-295X.85.2.59
Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin*, *114*(3), 510. https://doi.org/10.1037/0033-2909.114.3.510
Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39* (6), 1161. https://doi.org/10.1037/h0077714
Scherer, L. D., & Larsen, R. J. (2011). Cross-modal evaluative priming: Emotional sounds influence the processing of emotion words. *Emotion*, *11* (1), 203–208. http://doi.apa.org/getdoi.cfm?doi=10.1037/a0022588
Sollberger, B., Rebe, R., & Eckstein, D. (2003). Musical chords as affective priming context in a word-evaluation task. *Music Perception*, *20*(3), 263–282. https://doi.org/10.1525/mp.2003.20.3.263
Spruyt, A., De Houwer, J., & Hermans, D. (2009). Modulation of automatic semantic priming by feature-specific attention allocation. *Journal of Memory and Language*, *61*(1), 37–54. https://doi.org/10.1016/j.jml.2009.03.004
Spruyt, A., Houwer, J. D., Everaert, T., & Hermans, D. (2012). Unconscious semantic activation depends on feature-specific attention allocation. *Cognition*, *122* (1), 91–95. http://www.sciencedirect.com/science/article/pii/S0010027711002186.
Steinbeis, N., & Koelsch, S. (2011). Affective priming effects of musical sounds on the processing of word meaning. *Journal of Cognitive Neuroscience*, *23*(3), 604–621. https://doi.org/10.1162/jocn.2009.21383
Stoet, G. (2010). Psytoolkit: A software package for programming psychological experiments using linux. *Behavior Research Methods*, *42*(4), 1096–1104. https://doi.org/10.3758/BRM.42.4.1096
Stoet, G. (2017). Psytoolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology*, *44*(1), 24–31. https://doi.org/10.1177/0098628316677643

Storbeck, J., & Clore, G. L. (2008). Affective arousal as information: How affective arousal influences judgments, learning, and memory. *Social and Personality Psychology Compass*, *2* (5), 1824–1843. https://doi.org/10.1111/j.1751-9004.2008.00138.x

Vastfjall, D. (2001). Emotion induction through music: A review of the musical mood induction procedure. *Musicae Scientiae*, *5* (1 suppl), 173–211. https://doi.org/10.1177/10298649020050S107

Warriner, A. B., Kuperman, V., & Brysbaert, M. (2013). Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behavior Research Methods*, *45*(4), 1191–1207. https://doi.org/10.3758/s13428-012-0314-x

Yuan, J., Chen, J., Yang, J., Ju, E., Norman, G. J., & Ding, N. (2014). Negative mood state enhances the susceptibility to unpleasant events: Neural correlates from a music-primed emotion classification task. *PLoS ONE*, *9*(2 e89844 https://doi.org/10.1371/journal.pone.0089844).

Zhang, Q., Kong, L., & Jiang, Y. (2012). The interaction of arousal and valence in affective priming: Behavioral and electrophysiological evidence. *Brain Research*, *1474*, 60–72. https://doi.org/10.1016/j.brainres.2012.07.023

Zhang, J. D., & Schubert, E. (2019). A single item measure for identifying musician and non-musician categories based on measures of musical sophistication. *Music Perception*, *36*(5), 457–467. https://doi.org/10.1525/mp.2019.36.5.457

Zillmann, D., Katcher, A. H., & Milavsky, B. (1972a). Excitation transfer from physical exercise to subsequent aggressive behavior. *Journal of Experimental Social Psychology*, *8*(3), 247–259. https://doi.org/10.1016/S0022-1031(72)80005-2

Zillmann, D. (1983). Transfer of excitation in emotional behavior Cacioppo, John, Petty, Richard . *Social Psychophysiology: A Sourcebook*. New York: Guilford Press, 215–240.

Appendix A. Instructions for the priming tasks

Word Classification Task.

Instructions: In this task, you will see a series of words. If the word has negative connotations, press the ‘**z**’ key, if the word has positive connotations, press the ‘**m**’ key. Please respond within 2 seconds.

Each word will be preceded by a short audio clip.

You will now do a few practice attempts.

Press Space to start

Word Classification Task

As before, you will see a series of words. Press ‘z’ when you see a word with negative connotations and ‘m’ for positive connotations.

However, in this task there will be no indication whether or not your response is ‘correct’

Press Space to start

Word Classification Task

In this task you will see a sequence of words.

If the word is associated with **calm/still/relaxed** (ie low arousal) press the ‘**z**’ key

If the word is associated with **energy/activation/excitement** (ie high arousal) press the ‘**m**’ key

Each clip will be preceeded by a short audio clip: respond to the word not the sound.

You will now do a few practice attempts.

Press Space to continue

Word Classification Task.

Again, you will see a series of words, preceded by audio clips. If the word is associated with **calm/relaxed/still**, press the ‘**z**’ key, if the word is associated with **excitement/arousal/energy**, press the ‘**m**’ key. Please respond within 2 seconds.

However, in this task there will be no indication whether or not your response is ‘correct’

Press space to continue

Lexical Decision Task

You will now see a series of words on the screen. Some of the words will be real words. Some of the words will be nonsense words (pseudowords).

Each word will be a preceded by a short music clip.

If the word is a real word, press the ‘m’ key

If the word is a nonsense word press the ‘z’ key

Please answer as quickly and accurately as you can

You will now do a few practice attempts

Press *Space* to continue

Lexical Decision Task

As before, you will see a series of words on the screen. Some of the words will be real words. Some of the words will be nonsense words

Each word will be a preceded by a short music clip.

If the word is a real word, press the ‘m’ key

If the word is a nonsense word press the ‘z’ key

Please answer as quickly and accurately as you can. During this part of the experiment, you will not receive any feedback as to whether or not your answer is correct.

Press *Space* to continue

Figure A1. Instructions for priming tasks.

Appendix B. Valence-Arousal Ratings for one-second extracts from musicstimuli

35 participants, who did not take part in the priming task, rated the 1s stimuli outlined in Table 1 on both valence and arousal dimensions on a 9-point Likert scale. The mean rating values are shown in Table B1.

Table B1 Mean valence and arousal ratings for 1000 ms music stimuli.

Stimulus	Valence	Arousal
PH1	6.1	7.0
PH2	7.3	6.3
PH3	5.9	7.0
PH4	6.2	7.4
PL1	4.2	2.9
PL2	6.1	3.0
PL3	6.7	2.7
PL4	6.3	3.5
NH1	4.9	7.5
NH2	3.5	7.7
NH3	2.9	7.3
NH4	2.4	7.5
NL1	4.8	3.0
NL2	5.0	2.9
NL3	5.4	3.2
NL4	4.2	3.2

The valence-arousal ratings for the stimuli are represented graphically in Figure B1.

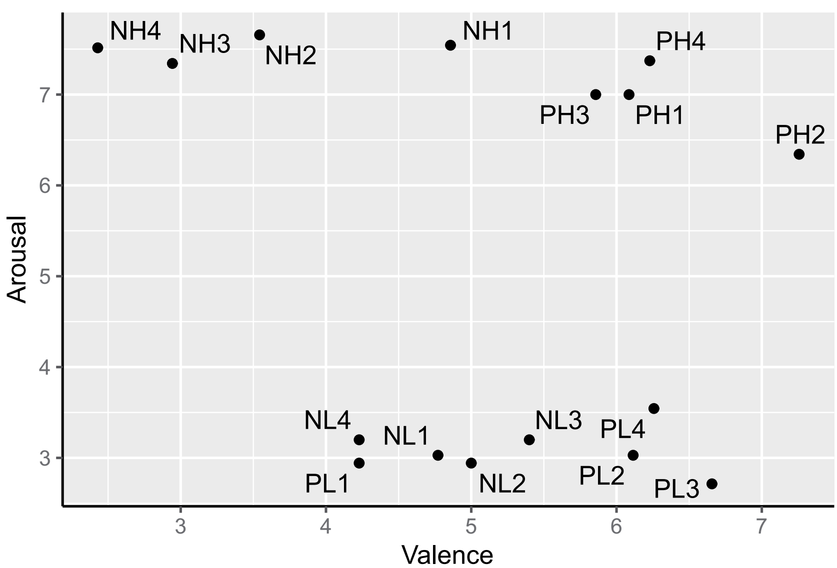

Figure B1. Valence-Arousal ratings for 1000 ms extracts from music stimuli.