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Music-Evoked Thoughts:
Genre and Emotional Expression of Music Impact Concurrent Imaginings

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Music listening can evoke a range of extra-musical thoughts, from colors and smells to autobiographical memories and fictional stories. We investigated music-evoked thoughts as an overarching category, to examine how the music's genre and emotional expression, as well as familiarity with the style and liking of individual excerpts, predicted the occurrence, type, novelty, and valence of thoughts. We selected 24 unfamiliar, instrumental music excerpts evenly distributed across three genres (classical, electronic, pop/rock) and two levels of expressed valence (positive, negative) and arousal (high, low). UK participants (N = 148, M_{age} = 28.68) heard these 30-second excerpts, described any thoughts that had occurred while listening, and rated various features of the thoughts and music. The occurrence and type of thoughts varied across genres, with classical and electronic excerpts evoking more thoughts than pop/rock excerpts. Classical excerpts evoked more music-related thoughts, fictional stories, and media-related memories, while electronic music evoked more abstract visual images than the other genres. Positively valenced music and more liked excerpts elicited more positive thought content. Liking and familiarity with a style also increased thought occurrence, while familiarity decreased

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During everyday life it is common to experience a range of thoughts, from autobiographical memories to plans about the future and fictional imaginings (**Berntsen & Jacobsen, 2008**; **Killingsworth & Gilbert, 2010**; **Warden et al., 2019**). Although such thoughts often come to mind quite spontaneously, the majority of involuntary autobiographical memories and involuntary future thoughts have identifiable external (i.e., perceptual) or internal (i.e., related to other thoughts or feelings) triggers (**Berntsen, 1996**; **Berntsen & Jacobsen, 2008**). In the related domain of research on mind-wandering, terminology such as "stimulus-independent thought" and "task-unrelated thought" has often implied a complete disconnection between one's current thoughts and any mental or perceptual cues preceding such thoughts (**Seli et al., 2018**; **Smallwood & Schooler, 2015**). However, several empirical and theoretical accounts have contradicted this idea. For instance, a person's current concerns and goals can impact their mind-wandering content (**Klinger, 2013**; **McVay & Kane, 2010**), and "automatic constraints"—perceptually or emotionally salient aspects of one's current environment—can influence the content and experience of mind-wandering (**Christoff et al., 2016**). Taken together, these various strands of previous research corroborate the idea that a person's immediate perceptual environment and associated mental states (e.g., emotional responses to that environment) impact the frequency, features, and content of their everyday thoughts.

One perceptual cue that frequently influences our everyday thoughts is music. Listening to music is a common trigger for autobiographical memories (**Jakubowski et al., 2023**; **Jakubowski & Ghosh, 2021**), fictional narratives (**Margulis, 2017**; **Margulis, Wong, et al., 2022**), visual imagery (**Dahl et al., 2022**; **Küssner & Eerola, 2019**; **Taruffi & Küssner, 2019**), and mind-wandering in general (**Taruffi, 2021**; **Taruffi et al., 2017**). Recent research has demonstrated that music can be a useful medium for investigating the interaction between a dynamically unfolding perceptual stimulus (e.g., the ongoing specific features of the music) and a person's past experiences and cultural associations in shaping the

particular musical features tend to elicit more positive or more novel thoughts.

Previous research on music-evoked thoughts (i.e., thoughts cued by listening to music) has been limited by a tendency to focus on specific categories of thoughts in isolation (e.g., autobiographical memories *or* fictional stories, **Jakubowski & Ghosh, 2021**; **Margulis, 2017**). The handful of broader studies on mind-wandering during music listening have typically explored responses to a small number of stimuli from the same musical genre (**Deil et al., 2022**; **Koelsch et al., 2019**; **Martarelli et al., 2016**; **Taruffi et al., 2017**; though see **Taruffi, 2021**, for an exception). These studies provide initial evidence that specific features of the music and participant-level differences in engagement impact the occurrence and content of music-evoked thoughts.

The Impact of Emotional Expression and Genre on Music-Evoked Thoughts

Previous research reveals clear links between the emotional expression of pieces of music and the features and content of the thoughts the music evokes. Significant emotional congruence effects of music cues on autobiographical memories have been identified, with more positive music eliciting more positive memories, and more arousing music eliciting more energetic memories (**Jakubowski & Eerola, 2022**; **Jakubowski & Francini, 2023**; **Schulkind & Woldorf, 2005**; **Sheldon & Donahue, 2017**). In addition, more positive and more arousing music elicits more social memories (**Sheldon & Donahue, 2017**) and less arousing music elicits more personally valued memories (**Jakubowski & Francini, 2023**). Sad music evokes more frequent, more self-referential, and less positive mind-wandering than happy music (**Taruffi et al., 2017**), while heroic music evokes more positive, energizing, and motivating thoughts than sad music (**Koelsch et al., 2019**). In addition, a recent study of music-evoked mind-wandering in everyday life showed that more positively valenced thoughts were reported in response to music that elicited more positively valenced emotions (specifically feelings of joy and power) (**Taruffi, 2021**). It is not yet fully understood how these emotional impacts of music on thoughts are underpinned by specific musical features (e.g., pitch, timbre, tempo), although one study has shown that faster music

cultural and contextual associations with particular genres are likely to vary systematically. For instance, a classical excerpt may elicit thoughts involving ballet dancers or concert halls and a rock excerpt may elicit thoughts of a music festival or bar, even if other features such as the emotionality and familiarity of these excerpts are similar (cf., "source sensitivity" effects; **Thompson et al., 2023**). However, research on specific types of music-evoked thoughts has tended to focus on single genres in isolation. For example, studies of music-evoked autobiographical memories often utilize pop music stimuli (e.g., **Belfi et al., 2016**; **Janata et al., 2007**), while various studies of music-evoked fictional narratives focus solely on instrumental art music (e.g., **Margulis, 2017**; **Margulis, Wong, et al., 2022**). As such, limited conclusions about the impact of genre on thought type and content can be drawn from the existing literature.

The Impact of Familiarity and Liking on Music-Evoked Thoughts

An individual's personal experiences with and appraisals of specific pieces and styles of music can also impact concurrent thoughts. For instance, music that is more familiar and more liked/enjoyed is more likely to trigger both autobiographical memories and imagined fictional narratives (**Jakubowski & Francini, 2023**; **Margulis et al., 2019**). More familiar and more liked music also evokes autobiographical memories more quickly, and greater liking of a piece of music is associated with more positive and energetic autobiographical memories (**Jakubowski & Francini, 2023**). In a live concert setting, participants who were more familiar with the musical artists had more thoughts that were concert-related and positive than those who were unfamiliar with the artists (**Deil et al., 2022**). Furthermore, individuals from the same cultural background exhibit greater similarities in written descriptions of their music-evoked narratives in comparison to individuals from different cultures (**Margulis, Wong, et al., 2022**), indicating that previous experiences influence not only the likelihood and appraisal of music-evoked thoughts but also their content.

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The Present Study

emotions are measured by their: 1) valence (variations in positivity/negativity), and 2) arousal (variations in activation/deactivation) (**Posner et al., 2005**; **Russell, 1980**). Given prior tendencies to study single genres in isolation (e.g., **Belfi et al., 2016**; **Deil et al., 2022**; **Janata et al., 2007**; **Koelsch et al., 2019**; **Margulis, 2017**; **Margulis, Williams, et al., 2022**; **Martarelli et al., 2016**; **Taruffi et al., 2017**), we expanded the scope of this previous work to compare thoughts reported in response to classical, electronic, and pop/rock excerpts. The features of thoughts that we focused on were: 1) the frequency of thought occurrence, to test whether certain music was more likely to evoke thoughts overall; 2) the type of thought that occurred (e.g., autobiographical memory, fictional story), to test whether certain music was more likely to elicit certain types of thoughts; and 3) the content of thoughts (e.g., emotionality, novelty), to test how features of music shape the specific mental imagery generated within each thought.

Our primary aims were to build a more comprehensive typology of thoughts evoked by music, and to examine how features of the music (emotional expression and genre) predict the occurrence, type, and content of these thoughts. A secondary aim was to investigate how participant-level differences in engagement with such music (specifically, familiarity and liking) impacted these thought features. In light of previous literature, we predicted that the content of thoughts would demonstrate emotional congruence with the emotional expression of the music, and that the content of music-evoked thoughts would differ across the three genres (**Jakubowski & Eerola, 2022**; **Taruffi, 2021**; **Thompson et al., 2023**). We also predicted that the occurrence of music-evoked thoughts would be positively related to liking and familiarity with the style (**Jakubowski & Francini, 2023**; **Margulis, 2017**). All other analyses were exploratory, given the lack of previous research in this domain.

Method

Design

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We tested the effects of genre (classical, electronic, pop/rock), expressed valence (positive, negative), and expressed arousal (high, low) of music, as well as participant

content was primarily assessed in terms of each thought's emotional valence (measured via automated sentiment analysis performed on the thought descriptions) and its novelty (measured via participant ratings). In a descriptive, exploratory analysis, we also examined the most frequently occurring words in the thought descriptions elicited by each genre.

Materials/Stimuli

Music Stimulus Selection

Two online pilot studies were run with the aims of selecting music stimuli for the main study that were: 1) equally distributed across each genre category; 2) equally distributed across two levels of expressed emotional valence (positive, negative) and arousal (high, low) within each genre; 3) likely to be unfamiliar to participants; 4) prototypical examples of our selected genres, and 5) likely to evoke thoughts in the main study.

Pilot Study 1

Pilot Study 1 served aims 1–3 above. To identify potential excerpts, we consulted a review of stimuli used in 306 previous studies on music and emotions (**Warrenburg, 2020**). From this review, we identified and selected music excerpts from the stimulus sets constructed by **Aljanaki et al. (2017)**, **Altenmüller et al. (2002)**, **Fan et al. (2020)**, and **Huq et al. (2010)**.[1] Some of these pieces had some lyrics, but we extracted only 30-second excerpts containing no lyrics for our purposes. In Pilot Study 1, we used 125 30-second excerpts of instrumental music from the genres of classical, electronic, pop/rock,[2] and jazz. These genre category labels were taken directly from the previous studies from which we selected the stimuli. In the study, each participant heard a subset of stimuli, comprising 29–36 excerpts all from the same genre category. Participants rated the expressed valence and arousal of each excerpt (on 7-point scales, assessing how negative/positive the emotion expressed by the music was and how low/high the energy level the emotion expressed by the music was, respectively). They were also asked whether they had ever heard each excerpt before (with response options of "Yes," "No," or "Not Sure"). If they answered "Yes" or "Not Sure" to this question, they were asked

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Following Pilot Study 1, we reduced our stimulus set to relatively unfamiliar excerpts by: 1) excluding excerpts for which the percentage of "No" responses to the question on whether an excerpt had ever been heard before was less than 90%; and 2) excluding excerpts for which even one participant was able to name the piece of music correctly. We also excluded excerpts for which the mean emotion ratings fell near the midpoint of the valence or arousal rating scale (e.g., the excerpt did not definitively convey positive or negative valence), to ensure the excerpts we used were clear examples of our emotion categories (e.g., positive *or* negative valence). We also excluded the jazz genre from further consideration, as the selected excerpts did not cover the emotion categories as comprehensively as the other three genres (i.e., very few of our jazz excerpts expressed both negative valence and low arousal).

Pilot Study 2

Pilot Study 2 served aims 4–5 listed in the *Music Stimulus Selection* section. We used 60 (20 from each genre) of the original 125 excerpts. We asked 121 participants (age range = 19–35 years, M = 27.76, SD = 4.86; 60 female, 57 male, 3 other gender, 1 preferred not to disclose a gender; all native English speakers and UK residents) to listen to 20 excerpts each (including excerpts from all three genres). After hearing each excerpt, they were asked to choose from a list any types of thoughts that had come to mind while they had been listening to the music (same list used in the main study; see **Appendix A**), describe in writing the everyday context in which they thought they would most likely hear such music, and choose a genre label that best fit the excerpt (from a list containing the genres classical, electronic, pop, and rock). Participants were panelists on Prolific who had not completed Pilot Study 1.

Following Pilot Study 2, we excluded 14 excerpts where fewer than 68% of participants' genre classifications of the excerpts matched our own genre labels, to ensure the excerpts we used were relatively prototypical examples of the three selected genres. We also excluded another 6 excerpts for which 8 or more participants (> 6.6%) reported that no thoughts had been evoked by the music, to ensure the excerpts we used in the main

Main Study Questions and Tasks

In the main study, after hearing each musical excerpt in its entirety, participants were asked whether any thoughts had come to mind while they were listening to the music. If they answered "Yes," they were asked to spend about one minute writing about the thoughts they had experienced. If they answered "No," they were asked to spend about one minute writing about why they thought no thoughts had come to mind. If thoughts were reported, they then completed rating scales on the degree to which the thoughts were prompted by the music and whether these thoughts were memories of previous experiences versus newly imagined (i.e., contained novel content). They were also asked to choose from a list of 9 options any types of thoughts they had experienced (e.g., thoughts about the music, fictional stories, memories from their lives, etc.); more than one option could be selected as relevant. This list of thought categories was composed based on previous literature (e.g., **Küssner & Eerola, 2019**; **Taruffi & Küssner, 2019**; **Taruffi et al., 2017**). Regardless of whether thoughts were reported, for each musical excerpt they were also asked if they had heard it before, how familiar it sounded, and how much they liked it. A full list of questions is provided in **Appendix A**.

Questionnaires

To control for factors that might moderate the occurrence of music-evoked thoughts, we asked all participants to complete the Four-Factor Imagination Scale (FFIS; **Zabelina & Condon, 2020**), which measures individual differences in the overall frequency, complexity, emotional valence, and directedness of imagination, and the Absorption in Music scale (AIMS; **Sandstrom & Russo, 2013**), which assesses one's ability and willingness to be absorbed by music. Previous research has shown that scores on the AIMS correlate positively with the tendency to imagine fictional stories while listening to music (**Margulis, 2017**). To provide an overview of our sample's music preferences, we used the Short Test of Music Preferences (STOMP; **Rentfrow & Gosling, 2003**), which solicits preference ratings for 14 genres of music, including those used in our stimulus set. To provide a brief demographic overview of participants' musical backgrounds we utilized one question from the Ollen Musical Sophistication Index on self-reported

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Participants in the main study were 148 adults aged 18-35 years (*M* = 28.68; *SD* = 4.58; 76 female, 69 male, 3 other gender). All reported they were currently living in the UK and spoke English as a native language. Around 34% of the sample reported having completed high school or A Levels as their highest qualification, 49% were either undergraduate students or had completed an undergraduate degree as their highest qualification, and 16% were either currently pursuing or had attained a postgraduate degree. None reported a hearing impairment and only two reported a visual impairment (wearing glasses, in both cases). 78% classified themselves as non-musicians, [4] and 82% had received 2 or fewer years of music training.

Paired-samples *t*-tests on STOMP scores indicated our participant sample preferred pop (*M* = 5.49, *SD* = 1.23) and rock music (*M* = 5.31, *SD* = 1.58) over both classical (*M* = 4.11, *SD* = 1.79) and electronic [5] (*M* = 4.39, *SD* = 1.75) music, all *p*s < .001. No significant difference was found in ratings of preference for classical versus electronic music, $t(147) = -1.35$, $p = .18$, or pop versus rock music, $t(147) = -1.23$, $p = .22$.

Participants were panelists on Prolific who had not completed either pilot study. All participants in both the main and pilot studies were compensated at a rate of £8.00/hour. This research received ethical approval from Durham University Music Department Ethics Committee.

Procedure

In the main study, after providing informed consent each participant completed demographic questions (e.g., age, gender). They then heard 12 of the 24 stimuli (one excerpt from each valence/arousal pairing from each genre) in a random order. They were asked to mentally note any thoughts or images that came to mind (regardless of whether they were related to the music). Participants were encouraged to relax and listen in a quiet environment, and we emphasized that there were no right or wrong answers to this task. Participants were also told that having no thoughts was a valid response, and if that was the case this should be reported as such. After hearing each stimulus, they completed the questions about their thoughts (or lack of thoughts) and

Prior to all analysis we excluded the 18 trials (1% of the dataset) for which participants gave a rating of 1 or 2 in response to the question "To what degree do you think these thoughts were prompted by the music you just heard?" to focus our analyses on thoughts that were at least partially prompted by the music.[6] We also excluded 28 trials (< 2% of the dataset) in which a participant reported "Yes" to the question of whether they had heard an excerpt before, given our aim to study responses to unfamiliar music. On 10% of the remaining trials participants reported they were "Not Sure" as to whether they had heard the excerpt before; however, on none of these trials was a participant able to name the title of the piece of music they had heard correctly.

Automated sentiment analysis was used to assess the overall valence of the words in the written thought descriptions. For each thought description, each word was classified as positive, negative, or neither, using the Bing sentiment lexicon as implemented in the R package "syuzhet" (**Jockers, 2015**). Each positive word received a score of +1 and each negative word received a score of -1; these scores were then summed and divided by the total number of words in each thought description, to control for the varying lengths of thought descriptions. Thus, each thought description could attain a total sentiment score ranging from -1 to +1.

Mixed effects models were used to test the effects of stimulus- and participant-level factors on thought features. Mixed effects models were chosen because they use a precision weighted average to model individual participants as a random factor and thus can account for the multiple and unequal distribution of responses across participants (**Janssen, 2012**; **Raudenbush & Bryk, 2002**), in this case the fact that not all participants reported thoughts in response to all stimulus types. The same approach has been adopted in previous music psychological studies using a similar design (e.g., **Belfi, 2019**; **Jakubowski et al., 2018**; **Jakubowski & Francini, 2023**).

Our first analysis focused on assessing whether the *occurrence* of thoughts (regardless of thought type) varied in relation to the stimulus- and participant-level variables of interest. Specifically, we used a binomial mixed effects model to predict whether a thought occurred or not, with genre of the excerpt (classical, electronic, or pop/rock),

We also conducted a second analysis predicting whether a thought occurred in relation to specific thought types. Here, our goal was to explore the different *types* of thoughts that were reported and, specifically, how the occurrence of different thought types varied in relation to the musical stimulus features. To categorize the type of thought(s) experienced, participants selected from a list of 9 response options (and could select multiple options per trial if desired). Three of these 9 categories were excluded from further analysis, given the relatively low number of responses falling into these thought categories: "I had thoughts about the future or personal plans" (4% of trials), "I was thinking about everyday stuff" (3% of trials), and "Other (please specify)" (0.3% of trials).[7] For the remaining thought categories, we fit a binomial mixed effects model predicting whether a particular thought type occurred on each trial or not, with thought type (6 levels), genre, valence, and arousal of the music excerpt as predictors. Crucially, we included the two-way interactions of thought type with genre, valence, and arousal, to examine whether the type of thought reported varied depending on musical stimulus features.

For the analyses predicting thought content, specifically valence (i.e., sentiment scores) of thoughts and novelty ratings of thoughts, we used linear mixed effects models. Genre, emotional valence, and emotional arousal of the excerpt, the two- and three-way interactions of these three music-related variables, as well as familiarity and liking ratings for each trial, were included as fixed effects in the models, with "Participant" as a random effect.

All mixed effect models were fitted using the "lme4" R package (**Bates et al., 2015**) and the overall statistical significance of each of the fixed effects/interactions was assessed with Wald χ^2 tests via the Anova() function in the "car" package (**Fox & Weisberg, 2019**). Post hoc pairwise comparisons and estimated marginal means from the models were computed using the "emmeans" package (**Lenth, 2022**). We also used the "tm" (**Feinerer et al., 2008**) and "wordcloud" (**Fellows, 2018**) packages in R to explore and visualize the most frequently used words in the thought descriptions. The main study data are available at: **https://osf.io/8cf5q/**.

elicited some thoughts, with 41 to 67 thoughts per clip (each clip was heard by 74 participants). All participants reported some thoughts, with 3 to 12 thoughts reported per participant (out of a possible 12). The mean rating of how familiar the music sounded across all excerpts was 2.41 (*SD* = 0.66) and the mean liking rating was 2.89 (*SD* = 0.60) (on 5-point scales). The number of music-evoked thoughts reported by each participant was not significantly correlated with scores on the AIMS or any of the dimensions of the FFIS (*rs* < .12, *ps* > .14), indicating that responses on our task were relatively unaffected by individual differences in musical absorption and imaginative capacities.

Occurrence of Music-Evoked Thoughts

To test for differences in the occurrence of thoughts, we fitted a binomial mixed effects model predicting whether a thought occurred, the results of which are presented in **Table 1**. The significant effect of genre was further explored in post hoc pairwise comparisons with Bonferroni correction, which revealed that both classical (estimated marginal mean (*EMM*) = 2.32, *SE* = 0.18) and electronic excerpts (*EMM* = 2.01, *SE* = 0.17) were more likely to elicit thoughts than pop/rock excerpts (*EMM* = 1.20, *SE* = 0.15), *ps* < .001, with no significant difference between classical and electronic excerpts, *p* = .28. Negatively valenced music also elicited significantly more thoughts (*EMM* = 2.15, *SE* = 0.16) than positively valenced music (*EMM* = 1.54, *SE* = 0.14), *p* < .001. The interaction between genre and arousal revealed that the high arousal electronic music elicited more thoughts than the low arousal electronic music,[8] *p* < .001, with no difference between high and low arousal excerpts for the other two genres, *ps* > .31. In addition, both familiarity (β = 0.65, *SE* = 0.08) and liking ratings (β = 0.87, *SE* = 0.08) of the individual excerpts were significant positive predictors of whether a thought occurred.

Table 1.

Results of Wald χ^2 Tests Assessing the Statistical Significance of Predictors of Whether a Thought Occurred

Predictor	χ^2	*df*	*p*
Genre	40.28	2	< .001***

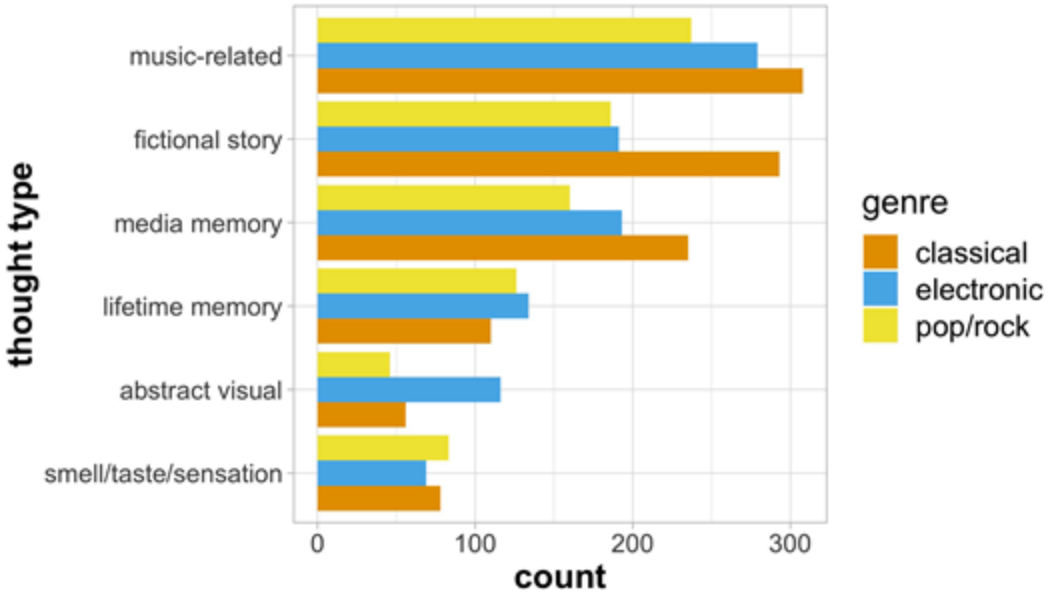
Familiarity	60.51	1	< .001***
Liking	115.84	1	< .001***
Genre × Valence	0.72	2	.70
Genre × Arousal	11.45	2	.003**
Valence × Arousal	0.12	1	.74
Genre × Valence × Arousal	2.22	2	.33

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

When an excerpt *did not* evoke any thoughts, we asked participants to describe in writing possible reasons for this. Common themes emerging from these descriptions were that the music was unfamiliar, boring, neutral, disliked, not to their taste, or chaotic sounding. In some cases, however, participants explicitly stated that they liked the music but were too busy focusing on it to experience other thoughts. In one case a participant stated that they tend to listen to music to clear their mind of other thoughts.

Types of Music-Evoked Thoughts

Figure 1 shows the frequency of the 6 primary thought types selected across all trials by genre (note that participants could select more than one thought type per trial). Examples of thought descriptions for each of these 6 thought types are provided in **Appendix C**. The results of a binomial mixed effects model showed statistically significant effects of thought type and genre (see **Table 2**). Post hoc, Bonferroni-corrected pairwise comparisons revealed that thoughts about the music were more frequently reported than all five other thought types (all *p*s < .001), thoughts involving fictional stories were more prevalent than lifetime memories, media-related memories, abstract visual images, and smells/tastes/sensations (all *p*s < .04), media-related memories were more prevalent than lifetime memories, abstract visual images, and smells/tastes/sensations (all *p*s < .001), and lifetime memories were more prevalent than abstract visual images and smells/tastes/sensations (*p*s < .001). The main effect of genre



Number of thoughts reported by thought type and genre.

Table 2.

Results of Wald χ^2 Tests Assessing the Statistical Significance of Predictors of Whether a Thought Occurred, as Predicted by Thought Type, Genre, Valence, and Arousal

Predictor	χ^2	*df*	*p*
Thought Type	818.60	5	< .001***
Genre	50.78	2	< .001***
Valence	0.69	1	.41
Arousal	3.55	1	.06
Thought Type × Genre	102.94	10	< .001***
Thought Type × Valence	8.84	5	.12
Thought Type × Arousal	17.22	5	.004**

excerpts evoked more thoughts about the music (*p*s < .001), more fictional stories (*p*s < .001), and more media-related memories (*p*s < .02) than both other genres. Electronic music excerpts evoked more abstract visual imagery than both other genres (*p*s < .001). No statically significant differences between the three genres emerged for lifetime memories or smells/tastes/sensations. The significant interaction between thought type and arousal was further explored via Bonferroni-corrected comparisons for high versus low arousal stimuli for each thought type. These revealed only one statistically significant difference: high arousal excerpts were more likely to evoke media-related memories (*p* < .001).

Content of Music-Evoked Thoughts

In a linear mixed effects model (see **Table 3**), we found that valence of the music was a significant predictor of valence of the thought descriptions; specifically, positively valenced music was associated with more positive sentiment scores for the thought descriptions (*EMM* = 0.024, *SE* = 0.004) than negatively valenced music (*EMM* = -0.008, *SE* = 0.004), *p* < .001. Liking of the music excerpt was also associated with more positive thought descriptions (β = 0.009, *SE* = 0.002).

Table 3.

Results of Wald χ^2 Tests Assessing the Statistical Significance of Predictors of Sentiment Scores

Predictor	χ^2	*df*	*p*
Genre	3.11	2	.21
Valence	41.10	1	< .001***
Arousal	0.62	1	.43
Familiarity	0.21	1	.64
Liking	11.91	1	.001**
Genre × Valence	4.97	2	.08

Genre × Valence × Arousal	2.92	2	.23

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

In the linear mixed effects model predicting ratings of the degree to which the thoughts contained novel imagined content (rather memories of something one had experienced before) (see **Table 4**), genre was a statistically significant predictor, with subsequent Bonferroni-corrected pairwise comparisons revealing that classical excerpts (*EMM* = 3.03, *SE* = 0.07) evoked more novel content than pop/rock excerpts (*EMM* = 2.78, *SE* = 0.07), $p = .003$ (all other *p*s > .13). Familiarity was negatively related to imagined content ($\beta = -0.32$, *SE* = 0.03); that is, less familiar sounding excerpts evoked more novel content. An interaction between genre and valence was driven by the fact that negative electronic music excerpts elicited more novel content than positive electronic music excerpts,[9] $p = .02$, with no differences between positively and negatively valenced excerpts from the other two genres, *p*s > .24.

Table 4.

Results of Wald χ^2 Tests Assessing the Statistical Significance of Predictors of the Degree to Which Thought Content was Novel

Predictor	χ^2	*df*	*p*
Genre	11.93	2	.003**
Valence	0.66	1	.42
Arousal	2.86	1	.09
Familiarity	96.70	1	< .001***
Liking	0.69	1	.41
Genre × Valence	6.58	2	.04*
Genre × Arousal	4.55	2	.10

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

On an exploratory basis, we examined the most frequently occurring words in the thought descriptions, which suggested some level of conceptual similarity in imaginings evoked by the same genre. **Figure 2** displays word clouds of the most frequently occurring words in thought descriptions by genre, after removing stop words (e.g., “and,” “the”) and words that referred to the task rather than its content (e.g., “remember,” “imagine”).[10] These results suggest that imaginings evoked by music may be constrained by the specific contexts in which one expects to hear, or has previously heard, such music. For instance, as seen in the word clouds, classical music often evoked thoughts related to films/movies, dancing/ballet, weddings, and orchestras. Electronic music evoked thoughts related to video games, dancing, and nightclubs. The frequency of occurrence of the same words across different thoughts in response to pop/rock music was somewhat lower, as indicated by the smaller text size in the word cloud, suggesting less similarity in the thoughts of different participants (and/or across the different pop/rock excerpts), but these stimuli generally evoked thoughts involving bands, films/movies, driving/cars, and live performances (concerts, festivals).

Figure 2.

Words reported in thought descriptions at least 15 times for each genre (from left to right: classical, electronic, pop/rock). Word size corresponds to frequency of appearance (larger words = more

hear such music. In this pilot study, for the classical excerpts, the most frequently mentioned contexts were “concert,” “movie,” and “theatre,” for the electronic excerpts the most frequent contexts were “movie,” “game/video game,” and “club,” and for the pop/rock excerpts these were “movie,” “car,” and “concert.”

Interestingly, we also noted various examples in the dataset where different types of thoughts evoked by the same music contained similar content. For example, one music excerpt prompted an autobiographical memory of “driving down a country road in America in the sun” and a fictional story of “a country scene of a car driving through beautiful scenery with big green meadows and clear blue skies.” This suggests certain music excerpts prime similar schematic representations regardless of the *type* of thought evoked, or whether the content of the thought is fictional or not. Such associations should be explored further in studies designed to test explicitly the semantic similarity between different thought types evoked by the same music.

Discussion

The present study examined the occurrence, type, and content of thoughts evoked when listening to unfamiliar music. Music-evoked thoughts were common across all participants and stimuli, and a range of different thought types emerged, from abstract shapes and sensations to fictional stories. The occurrence and content of thoughts were influenced by both the genre and emotional expression of the music, as well as individual listeners’ liking and familiarity with the style of the excerpts.

Effects of Genre and Emotional Expression on Thought Features

The genre of the music excerpts impacted the occurrence, type, and content of thoughts. Classical and electronic excerpts evoked more thoughts overall than pop/rock excerpts. In particular, the classical excerpts evoked more thoughts about the music, imagined fictional stories, and media-related memories than the other genres.

Paralleling this result, classical excerpts also evoked thoughts accompanied by higher ratings of novel content than pop/rock excerpts. On the other hand, the electronic

of) extra-musical thoughts. This aligns with the multiplicity of ways with which music is engaged, and the different "listening modes" afforded by music (**Tuuri & Eerola, 2012**). "Classical music" is a broad genre categorization, but within this genre there is a long history of various composers explicitly aiming to convey extra-musical programs. In addition, modern media and therapeutic usages of classical music often amplify the idea that classical music can be linked with visual images and narratives (e.g., the Disney film Fantasia, the Bonny Guided Imagery Method). Electronic music has similarly been found to be associated with mind-wandering, and visual mental imagery in particular, during live concerts (**Deil et al., 2022**) and in everyday listening scenarios (**Taruffi, 2021**). Pop and rock music, on the other hand, might invite other modes of engagement, such as embodied responses (e.g., dancing or singing along), more frequently than mental imagery or fictional narratives. It should be noted that pop and rock music often contain lyrics, although our study focused on instrumental excerpts of these genres. It therefore may be that pop and rock music elicit narrative engagement and visual imagery primarily via their lyrics, rather than the structural features of the music itself.

The emotional expression of the music had comparatively fewer effects on thought occurence and thought type than genre. Negatively valenced music elicited more frequent thoughts, which parallels previous findings that sad music evokes more mind-wandering than happy music (**Taruffi et al., 2017**) and mind-wandering is more likely to occur in negative mood states (**Killingsworth & Gilbert, 2010**; **Smallwood et al., 2009**). However, this effect of valence on thought occurrence disappeared when the type of thought was taken into account (see **Table 2**). It may therefore be that negative valence has less systematic impact on thoughts that are more tightly coupled to the musical stimulus (e.g., music-related thoughts, media-related memories) than it does in general mind-wandering studies, which also typically include thoughts less directly evoked by a particular stimulus. Other analyses revealed interaction effects (e.g., high arousal electronic music elicited more thoughts than low arousal electronic music, high arousal excerpts were more likely to evoke media-related memories), which suggest the emotional expression of excerpts does not uniformly impact the thoughts that are elicited, but rather, more nuanced patterns of results emerge in relation to particular

excerpts we selected sounded like music one might typically hear in a nightclub or video game, and thus might also simply have stronger existing contextual associations than the low arousal electronic excerpts. Such results require further exploration in future studies, given the relatively limited number of stimuli used here, to understand if such effects scale up or are simply artifacts of the particular excerpts we chose.

However, the valence of the music stimuli significantly impacted the valence of the thought descriptions, indicating that the emotional expression of music can impact the *content* of concurrent thoughts in an emotionally congruent way. This parallels previous findings on music-evoked autobiographical memories (**Jakubowski & Francini, 2023**; **Sheldon & Donahue, 2017**) and music-evoked mind-wandering (**Taruffi et al., 2017**), and suggests that, regardless of thought type, positive sounding music evokes more positive thought content than more negative sounding music. It should be noted that previous researchers primarily asked participants to rate the emotional valence of their thoughts, whereas here we used sentiment scores from their thought descriptions but obtained similar results, suggesting linguistic analysis of thought descriptions can be an effective proxy for self-reported valence ratings.

Effects of Familiarity and Liking on Thought Features

Familiarity ratings of the music positively predicted thought occurrence. All excerpts were confirmed to be quite unfamiliar to this group of participants, and thus familiarity ratings in this context indexed the degree to which the music sounded stylistically similar to music the participants had heard before. This result parallels **Margulis (2017)**, who found that classical excerpts that were rated as more familiar sounding were more likely to evoke imaginings of fictional narratives. Interestingly, in our study, stimulus familiarity ratings were also a *negative* predictor of the degree to which the thought contents were rated as novel (as opposed to "memories of things you've seen/experienced before"). On a similar note, positive associations between music's familiarity and the occurrence of autobiographical memories have been reported in several previous studies (e.g., **Jakubowski & Francini, 2023**; **Janata et al., 2007**). Our findings indicate that thoughts evoked by more familiar sounding music are more likely

creativity and divergent thinking, and future work could consider how listening to music of varying degrees of familiarity facilitates or inhibits the generation of new ideas.

Liking of the music excerpts was also a positive predictor of thought occurrence. This replicates previous findings that liking of music excerpts predicts more autobiographical memories (**Jakubowski & Francini, 2023**) and more imagined fictional narratives (**Margulis, 2017**), extending these results to music-evoked thoughts more broadly. This finding also aligns with the fact that when participants did not experience any music-evoked thoughts they often attributed this to the music being boring or unappealing. Interestingly, the participants in our study rated their overall preferences (via the STOMP) for pop and rock music significantly higher than classical and electronic music, whereas classical and electronic excerpts both evoked more thoughts in our study than pop/rock excerpts.[11] Taken together, these results suggest that liking on a stimulus-level basis is a more elucidative factor in predicting the occurrence of music-evoked thoughts than overall genre preference ratings.

Liking was also positively associated with thought valence. This suggests that listening to music that aligns more with one's tastes can lead to more positive thought content (independently of the valence of the music itself, which also predicted thought sentiment scores). A similar result has been reported in research on autobiographical memories, in which more liked music evoked autobiographical memories that were rated as more positive (**Jakubowski & Francini, 2023**). However, future research should investigate the causal direction of this effect, as it could also be that music that evokes more positive thoughts leads listeners to appraise this music more favorably.

Additional Results: Thought Types and Contextual Associations

When considering the types of thoughts that were evoked overall, perhaps unsurprisingly, thoughts about the music itself were the most frequently reported thought type in our study (see **Figure 1**). However, a large number of fictional stories and media-related memories also emerged. This provides further evidence that narrative engagement is a common response to music (**Margulis, 2017**; **Margulis, Wong, et al.,**

associations linked to them (**Jakubowski & Francini, 2023**; **Janata et al., 2007**). Future research should investigate how the distributions of such thought types change in response to music of more varying familiarity levels. In addition, thoughts about the future, personal plans, or "everyday stuff" were very infrequent. This may be because we excluded thoughts that were not at least partially prompted by the music, and our use of relatively short (30 s) music excerpts may have facilitated more task-related thoughts. Previous work using longer listening periods (5 minutes) has found a greater prevalence of thoughts that were less directly related to the music (**Taruffi, 2021**).

Finally, the contexts in which we typically hear music seem to be an underpinning factor in the types of thoughts we experience (see **Figure 2**). This aligns with the recently proposed concept of source sensitivity, which "involves identifying and engaging with the causes and contexts of music making" (**Thompson et al., 2023**, p. 261) and has been proposed as a major source as to why humans appreciate music. That is, evaluation of music is not only driven by appraisals of the stimulus features (e.g., rhythm, melody), but also knowledge and understanding of how, when, and where it is produced, including its cultural context. Future research should strive to identify these contextual associations with music, as well as the degree to which our appreciation of the music is impacted by such associations. Subsequent studies should also test whether groups with different contextual associations with specific genres exhibit differences in the content of music-evoked thoughts. For instance, classical and electronic music fans (or musicians) could be recruited to test whether the associations seen here between classical music and films or weddings and electronic music and video games or nightclubs might shift to a more complex pattern of associations in those with more extensive experiences in engaging with these genres.

Limitations

There are several limitations to the current approach that should be noted. Although we instructed participants that having no thoughts was a valid response, some may still have felt compelled to report thoughts. Future research should aim to assess the spontaneity or involuntary nature of music-evoked thoughts to understand further if

instance, the classical excerpts contained Baroque, classical period, and more contemporary excerpts, and it is likely that each of these subgenres carries different associations that may lead to different thought content. The instructions used in our task were also relatively open; we did not ask participants to adopt a particular listening mode (**Clarke, 2005**; **Tuuri & Eerola, 2012**) or to focus on particular aspects of the music. Future research could assess whether instructions that encourage listeners to focus on the music in different ways also change the types and contents of associated thoughts. Finally, subsequent research in this area should consider listening context as a potentially important factor, by assessing music-evoked thoughts in diverse ecological settings such as live performances and background listening at home, to assess the role of social, attentional, and motivational factors.

Conclusion

In conclusion, the findings of the present study demonstrate that listening to music can evoke an array of extra-musical thoughts. The occurrence and type of thoughts evoked vary across genres, and the emotional expression of music can lead to emotionally congruent thoughts. Familiarity with a style increases the occurrence of thoughts but decreases the novelty of the content of these thoughts. Liking of excerpts increases both the occurrence and positivity of thoughts. These findings have implications for how music may be used to elicit different types and contents of thoughts for creative and therapeutic purposes and open up a range of avenues for future research.

Author Note

The data that support the findings of this study are openly available at:
https://osf.io/8cf5q/

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1 These studies were selected as they used music excerpts expressing a range of emotions, at least some of which were unfamiliar to participants, and excerpts used in these studies were freely or commercially available for our use.

2 Pop and rock music were grouped together due to some ambiguity in distinguishing these genres, and to cover a wider range of emotion space. It is acknowledged that the high arousal music we utilized tended to be more toward the "rock" end of the spectrum and the low arousal excerpts were more towards the "pop" end.

3 Negative valence excerpts were defined as those given a mean valence rating of less than 4; positive valence excerpts were those given a mean valence rating of greater than 4. Low arousal excerpts were defined as those given a mean arousal rating of less than 4; high arousal excerpts were those given a mean arousal rating of greater than 4.

4 In accordance with the categories from the Ollen Musical Sophistication Index: *non-musician; music-loving non-musician; amateur musician; serious amateur musician; semi-professional musician; professional musician*

5 The STOMP genre labelled as "Dance/Electronica" was used for this analysis.

6 For these remaining trials, 67% were given the highest possible rating (5), indicating their thoughts were "entirely prompted by the music."

7 "Other" descriptions were reported on 5 trials, and typically comprised descriptions of felt emotions, or expansions on thought categories already reported.

8 One possible explanation for this result is a difference in familiarity between these groups of stimuli, as the high arousal electronic stimuli were rated as more familiar sounding than the low arousal electronic stimuli, $t(147) = 3.44$, $p < .001$.

9 This result may have emerged because negative electronic excerpts were rated as less familiar overall than positive electronic excerpts, $t(147) = -3.25$, $p = .001$.

Furthermore, a comparison of liking ratings in our study across each genre via paired-samples *t*-tests shows that the classical and pop/rock excerpts were more liked than the electronic excerpts overall (*p*s < .004), with no difference between the classical and pop/rock excerpts (*p* = .23).

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Appendix A

Questions Used in Main Experiment for Thought Reporting and Stimulus Ratings

[Response options in italics]

Did you imagine any other thoughts or scenes while listening to this music? *Yes / No*

[Shown if "Yes" response was provided to the first question]

Please describe the thoughts/scenes you imagined in as much detail as possible, but do not spend more than about a minute on the response. *Open text box*

To what degree do you think these thoughts were prompted by the music you just heard?

1 = not at all prompted by the music / 2 / 3 = partially prompted by the music / 4 / 5 = entirely prompted by the music

To what degree were these thoughts memories of things you've seen/experienced before, versus things you've newly imagined?

1 = entirely things I've seen/experienced before / 2 / 3 = a combination of things I've seen/experienced before and things I've newly imagined / 4 / 5 = entirely things I've newly imagined

Please tell us which of the following categories of thoughts you had while listening to the music.

Feel free to choose more than one option if you had multiple types of thoughts.

I had thoughts about the music. / I imagined abstract shapes, colours, or patterns. / I imagined smells, tastes, or other sensations. / I imagined a fictional story or scene. / I recalled memories of experiences from my life. / I recalled memories from media such

Why do you think you didn't imagine any thoughts or scenes during this music? Please answer this question in as much detail as possible, but do not spend more than about a minute on the response. *Open text box*

[Shown to all participants, regardless of whether thoughts were reported]

Have you ever heard this music clip before today? *Yes/ No / Not Sure*

[If "Yes" or "Not Sure" was selected in response to the previous question] What is the name of this piece of music? (If not sure, please make a guess) *Open text box*

How familiar did this music clip sound? *1 = very unfamiliar / 2 / 3 / 4 / 5 = very familiar*

How much did you like this music clip? *1 = disliked a lot / 2 / 3 / 4 / 5 = liked a lot*

Appendix B

Musical Stimuli Used in the Main Experiment

Label	Title	Composer/Artist	Genre	Valence	A
C_1F_PH	Trois Pieces Breves, I. Allegro	Ibert	Classical	Positive	H
C_2A_PH	Symphony No 5, 1st movement	Schubert	Classical	Positive	H
C_4F_PL	Trois Pieces Breves, II. Andante	Ibert	Classical	Positive	L
C_8E_PL	Concerti grossi Op. 6, No. 10, 1st movement	Corelli	Classical	Positive	L
C_4A_NH	L'Arbre des songes	Dutilleux	Classical	Negative	H
C_8A_NH	Violin and Piano Sonata No. 2	Antheil	Classical	Negative	H
C_3E_NL	Violin Sonata No. 5 in F minor, I. Largo	J.S. Bach	Classical	Negative	L
C_7A_NL	String Quartet	Webern	Classical	Negative	L
E_1381_PH	Out Of Season	Wisp	Electronic	Positive	H
E_395_PH	Spectrum (Subdiffusion Mix)	Foniqz	Electronic	Positive	H

E_1305_NH	Alone	The S.K.	Electronic	Negative	H
E_1357_NH	The Nosebleed	Ant The Symbol	Electronic	Negative	H
E_1368_NL	Be Sweet	The Kandis Project	Electronic	Negative	L
E_7H_NL	Red Lights	Carl Craig	Electronic	Negative	L
P_1808_PH	Emma	The Attraction	Pop/Rock	Positive	H
P_757_PH	Freeway	Kurt Vile	Pop/Rock	Positive	H
P_2A_PL	I Think it's Going to Work out Fine	Ry Cooder	Pop/Rock	Positive	L
P_3A_PL	Railroad Work Song	The Notting Hillbillies	Pop/Rock	Positive	L
P_14A_NH	Hard Lovin' Man	Deep Purple	Pop/Rock	Negative	H
P_1874_NH	Dance With Me	The Electric Nature	Pop/Rock	Negative	H
P_811_NL	Tourist Shooting Tar Balls	Party People in a Can	Pop/Rock	Negative	L
P_829_NL	Talk to me	Jahzzar	Pop/Rock	Negative	L

Appendix C

Examples of Thoughts from Each of the 6 Most Frequently Reported Thought Types

Thought Type	Examples
Music-Related	"I thought of a large speaker with heavy bass"
	"it made me feel quite stressed because everything sounded so chaotic and out of t
Fictional Story	"I pictured walking around an old haunted house, going up the staircase I felt quite
	"A Downton abbey type of ball came to mind, with ladies in fancy dresses and men
Media Memory	"About a year ago I re-watched Fantasia with my partner so this reminded me of tha
	"Really reminded me of Guitar Hero, a video game"

Abstract Visual	“This one kinda felt like i was zooming through space but a space with bright psych
	“This made me imagine a black space with light blue circles and rings flying across
Smells/Tastes/Sensations	“The music made me think of summer and feeling free, it wasn’t necessarily particu
	“I felt quite a cozy vibe from this I just thought about myself playing games on my c

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