Cognitive agency in music interventions: Increased perceived control of music predicts increased pain tolerance

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Abstract
Background: Self-selected music is consistently found to be the strongest predictor for successful music listening interventions in pain management contexts, but the specific cognitive mechanisms that mediate these effects are currently unknown.

Objectives: The aim of this study was to isolate the role of cognitive agency on pain tolerance in music listening interventions, independently from parallel effects related to enjoyment. Additionally, the study examines the role of intramusical features and individual attributes related to musical engagement.

Methods: Fifty-two participants completed a repeated measures experiment, which involved listening to six different pieces of music while completing the cold pressor task. Cognitive agency was operationalized by giving participants different degrees of perceived control over the music selection, when in fact it was pre-determined by the experimenter.

Results: A generalized linear mixed model was used to analyse the impact of perceived choice and intramusical features on pain tolerance measured in terms of duration on the cold pressor task, pain intensity and pain unpleasantness. Increased levels of perceived choice predicted increases in pain tolerance when enjoyment was accounted for. Individual levels of trait empathy and sophisticated emotional engagement with music also contributed to the effects. Intramusical features did not predict increases in pain tolerance.

Conclusions: This study demonstrates that the reason self-selected music is particularly effective in reducing pain is related to the act of making a choice over the music itself. This study provides support for the cognitive vitality model and emphasizes the importance of giving people as much control as possible in music interventions.

Significance: This study identifies that the act of selecting music contributes to increases in pain tolerance in parallel with the independent factor of enjoyment. This provides support for the role of cognitive agency in mediating the analgesic effects of music interventions, which suggests that people should be given as much control as possible in music interventions. Additionally, this study identifies specific individual attributes related to emotional engagement and empathy that amplify the effect of cognitive agency.
1 | INTRODUCTION

The importance of personal choice in music listening interventions (MLIs) for pain management (Mitchell & Mac Donald, 2006) has been replicated in several high-quality studies and meta-analyses (Bradt et al., 2015; Lee, 2016; Tsai et al., 2014). MLIs for pain management involve listening to live or recorded music, provided by a health professional or music therapist and rely on an active music listening experience as the primary therapeutic component (Finlay & Rogers, 2015; Howlin & Rooney, 2020).

The current focus in music intervention research moves beyond the basic sensory properties of music and considers the wider aspects of music engagement that facilitate sustained attention (Garza-Villarreal et al., 2017) and absorption (Garcia & Hand, 2016). Increasingly, it is recognized that cognitive (Bradshaw et al., 2012) and emotional (Garza-Villarreal et al., 2017) interactions mediate the analgesic benefits of music engagement (Garcia & Hand, 2016; Gold & Clare, 2013; Guéton et al., 2012). Yet the specific cognitive and emotional factors that contribute to the analgesic effects of MLIs have not yet been identified (Bradshaw et al., 2012; Garcia & Hand, 2016).

Recently, we produced a theoretical framework called the cognitive vitality model to develop a greater understanding of the cognitive mechanisms that mediate the analgesic effects of MLIs (Howlin & Rooney, 2020). The cognitive vitality model suggests that enhanced cognitive agency from music listening facilitates the top-down regulation of pain (See Figure 1; Howlin & Rooney, 2020). Cognitive agency refers to the subjective experience of having ownership of one’s actions, feelings and thoughts (Jeannerod, 2003), and music is considered as a resource that can enhance agency (Saarikallio et al., 2020). In pain management contexts, it has been shown that when patients are given more control over the music that they listen to, they experience a greater sense of perceived control over painful sensations (Garza-Villarreal et al., 2014; Linnemann et al., 2015; Mitchell et al., 2008). However, the degree to which the analgesic benefits of self-selected music are mediated by cognitive agency, as opposed to other co-founding factors present in self-selected music such as familiarity or enjoyment (Finlay & Anil, 2016; Noguchi, 2006; Rafer et al., 2015), has yet to be evaluated.

The magnitude of effect sizes seen across MLI research varies considerably (Bradt et al., 2015; Lee, 2016), potentially due to in part to differences in individual attributes such as age, musicality (Bradshaw et al., 2012; Finlay, 2014; Knussen & Serpell, 2007; Mitchell et al., 2008; Noguchi, 2006), or potential empathy (Vuokskoski et al., 2011) or autonomy. Contemporary definitions of musicality (or musical sophistication) in the general population encompass a broad range of active musical behaviours (performance, curation, listening or communication) as to form a multi-faceted concept of musical engagement, skills or expertise (Müllensiefen et al., 2014). Sophisticated emotional engagement is a subcomponent of musicality, which reflects the tendency to experience more rich or salient emotional responses to music. It is possible that musical sophistication could also enhance the effectiveness of MLIs. Additionally, neuroimaging studies have identified the role of the neural reward pathway (Dobek et al., 2014) and the default mode network (Garza-Villarreal et al., 2015) in mediating the analgesic effects of music interventions. This identifies that the role of enjoyment and reward needs to be controlled to understand the higher cognitive processes involved. Accordingly, this study examines the role of the individual attributes of age, musicality, empathy and autonomy to account for the degree to which they contribute to the analgesic effect of MLIs. The primary outcomes evaluated are level of choice and intramusical features, and individual attributes are examined as secondary outcomes.

1.1 | Hypotheses

Hypothesis 1 Is it possible to replicate previous findings that self-chosen music from an unlimited choice increases participants pain threshold?

Hypothesis 2a Cognitive agency mediates the analgesic effects of music listening.

Hypothesis 2b Intramusical features mediate the analgesic effects of music listening.
Hypothesis 2c Do individual attributes (enjoyment, age, trait empathy, musicality and autonomy) contribute to analgesic effects of music listening?

2 | STUDY AIM

The aim of the current study was to examine the relative contribution of cognitive agency and specific intramusical features on the analgesic effects of music listening, while accounting for individual attributes.

3 | METHOD

3.1 | Participants

A total of 52 people were recruited to participate via social media and university campus advertisements, which included 31 women and 21 men (See Table 1 for Participant Demographics). A minimum a priori sample size of 43 was calculated using G*Power for a repeated measures F test. The calculation was based on a small to medium effect size as indicated by the meta-analysis of music intervention studies for pain management conducted by Lee (2016). All participants were screened to ensure they met the full inclusion criteria (over 18 years of age) and the exclusion criteria (any medical requirement for analgesic medication or treatment; a condition of thermal hypersensitivity or hyposensitivity, a hearing impairment). All participants were self-reported to be free from acute or chronic pain and were instructed not to take any pain medication for 48 hr prior to the experimental study. One participant was excluded due to having thermal hyposensitivity. The group consisted of 29 (55%) undergraduate and postgraduate students, 20 (38.5%) people in full-time employment, 3 (5.7%) people who worked part-time or were unemployed. Participants were not provided with any incentive to participate. All participants provided informed consent in line with university ethics guidelines, and the study was approved by the investigator's institutional ethics committee.

3.2 | Measures

3.2.1 | Musicality

The Goldsmiths Musical Sophistication Index v1.0 (GMSI; Müllensiefen et al., 2014) was used to measure musicality because it has been designed for use with the general population and demonstrates strong reliability and psychometric validity. The GMSI is comprised of five subscales; active engagement, perceptual abilities, musical training, emotional engagement and singing abilities, which measure different aspects of cognitive and emotional engagement with music. Possible scores on the GMSI range from 18 to 126, with an average score of 81.58 across the general population (Müllensiefen et al., 2014). Participants responded on a 7-point Likert scale, which ranged from 'completely disagree' (1) to 'completely agree' (7).

3.2.2 | Empathy

The fantasy subscale of the Interpersonal Reactivity Index (IRI; Davis, 1983) was used as an indicator of trait empathy. The fantasy subscale taps respondents' tendencies to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies and plays. Possible scores on the fantasy subscale of the IRI range from 7 to 35. Participants respond on a 5-point Likert scale, which ranges from 'Does not describe me well' (1) to 'Describes me very well' (5).

3.2.3 | Autonomy

The autonomy subscale from Ryff's (1989) psychological well-being scales was used to measure autonomy. People with high levels of autonomy are characterized as self-determining and independent and do not feel pressured to conform to social norms. Possible scores on the autonomy subscale range from 6 from 42. Participants respond on a 6-point Likert scale ranging from 'Strongly agree' (1) to 'Strongly disagree' (6).

3.3 | Procedure

At the beginning of each session, the experimenter checked that each participant was eligible to take part in the study and each participant provided informed consent. Participants then
completed the baseline assessment (see below) for the cold pressor task, so that a comparison could be made between the experimental conditions and the baseline.

Next, a $3 \times 2$ factorial within-subject design was used to examine the degree to which perceived choice and intramusical features could account for the analgesic effects of music listening. Participants were asked to select a piece of music under three conditions (no choice, perceived choice from two songs or perceived choice from four songs), which were controlled for intramusical features (motivating, relaxing), while they completed the cold pressor task. During the cold-water task, participants could listen to the entire song on Sennheiser sound excluder headphones for the entire duration of the cold pressor task, and participants stopped listening to each piece of music once they removed their hand from the ice water bath. Participants had full control of the volume and were advised to listen to the music at a comfortable volume, to maximize the likelihood that participants would experience enjoyment in a laboratory setting. The experimenter was unable to tell which piece of music the participant was listening to in each trial as there was no name or label for each trial on screen. A Latin square design was used to randomize the order of the six music conditions, to account for any carry-over effects from the previous trial.

Following the $3 \times 2$ factorial experimental paradigm, participants were given an unlimited choice of music using the Spotify music database while completing the cold pressor task. This was performed to replicate previous findings and to validate the current experimental paradigm. Finally, at the end of the session, participants were asked to complete three questionnaires that measured individual attributes related to music engagement and well-being. This was carried out at the end of the session to minimize the risk that participants would be primed by the content of the questionnaires.

### 3.4 Perceived music choice paradigm

The perceived music choice paradigm was used to examine the impact of perceived choice on the analgesic benefits of music. Perceived level of music choice had three levels: no choice, perceived choice between two songs and perceived choice from four songs. The aim was to identify the minimum degree of choice required to elicit a perceived analgesic benefit. In the absence of previous research, these levels of choice were used to provide an initial test of the linearity of effects, while also being feasible in terms of the time demands and trials required for participants. A choice between two songs was the minimum number of songs that would constitute a choice. We wanted an additional condition between minimum choice and unlimited choice that would strike a balance between being a meaningful choice and what is feasible amount of time participants could be expected to sample possible choices. In advance of the study, it was not clear if selecting from two pieces of music would be sufficient to elicit an analgesic effect or whether a wider choice from four would be required to really make the participants feel that they were choosing from a variety of options. In each condition, participants listened to 3-s music clips and then selected which piece of music they wanted to listen to during the cold pressor task. Participants were naïve to the fact that they were listening to different parts of the same song, so the final ‘chosen’ song was predetermined by the experimenter in each trial. Once the music was selected, the participants completed the cold pressor task while listening to the piece of music that they had selected. Following this, participants placed their hand in warm water to bring it back to their normal body temperature, while they provided ratings for pain intensity, pain unpleasantness and emotional responses and enjoyment. This procedure was repeated for all six conditions of the perceived music choice paradigm.

### 3.5 Music stimuli

For this study, the intramusical features were manipulated as a second independent variable. A pilot study was used to select six pieces of music from an initial pool of 18 pieces of music which either had intramusical features that were relaxing, with a low tempo of 60–80 bpm, low levels of arousal and gentle rhythms; or motivating, with a high tempo of 100–110 beats per minute (bpm), high levels of arousal and danceable rhythms (See Table 2). To minimize the likelihood that songs would be
familiar the experimenters searched for songs on Spotify that were new releases with low play counts. There were no lyrics in any of the music stimuli to control for the potential impact of lyrics. In the pilot study, familiarity ratings were measured from six people on a continuous rating scale from 0 ‘not familiar at all’ to 10 ‘extremely familiar’, and all songs in the final experiment had a mean familiarity rating of 3 or lower (See Table 2). Participants in the main experiment verbally confirmed that they were not familiar with the music stimuli. All songs were commercially available pieces of music to maximize the ecological validity of the experiment. After listening to each piece of music during the cold pressor task, participants were asked to rate how much they enjoyed each piece of music on a 100-point enjoyment scale from ‘did not enjoy this at all’ (0) to ‘enjoyed this very much’ (100). At this point, participants were also asked to provide their emotional response to each piece of music in terms of nine different emotions highly associated with music engagement (activation, power, peacefulness, nostalgia, sadness, transcendence, wonder, tenderness, and tension) using the 5-point Geneva Emotional Musical Scale (GEMS-9; 23) from ‘Not at all’ (1) to ‘Very much’ (5).

### 3.6 Pain stimuli and baseline assessment

The Cold pressor task was used to stimulate pain. For the baseline assessment, participants submerged their non-dominant hand into a circulating ice water bath at 5°C and were instructed to remove it as soon as it became too uncomfortable to continue. Five degrees was chosen based on previous studies, which indicate that it is possible to simulate a painful sensation with an ice water bath held at 5°C (Mitchell, MacDonald, & Brodie, 2004). Duration on the cold pressor task was used as an objective indicator of pain tolerance. Once participants removed their hand from the ice water bath they had to rate the intensity and unpleasantness of the ice water. The 100-point intensity scale had three anchor points ‘no pain’ (0), ‘moderate pain’ (50) and ‘worst pain imaginable’ (100). The 100-point unpleasantness scale ranged from ‘not unpleasant’ (0) to ‘extremely unpleasant’ (100). Participants were also provided with an additional water bath at 30°C for as long as they needed to bring their hand back to a comfortable temperature after each time they completed the cold pressor task.

### 3.7 Validation of experimental conditions

At the end of the six conditions described above, participants completed an additional condition to validate the experimental paradigm. In this final condition, participants could select any piece of music they wanted from Spotify while they completed the cold pressor task. This condition was used to examine whether under these laboratory conditions self-selected music would lead to an increase in pain threshold or enjoyment, and data from this condition were not included in the main analysis.

### 3.8 Statistical analysis

Statistical analyses were performed using SPSS 26 (IBM Corp, 2019). To examine each part of the second hypothesis, the impact of the two independent variables, level of perceived music choice and music features, were analysed in relation to the dependent variable, pain tolerance using a generalized linear mixed model (GLMM). This provided a more sophisticated analysis method than a traditional repeated measures ANOVA because it accounted for enjoyment ratings from each specific music condition, along with individual attributes, which is not possible with a traditional ANOVA. Additionally, the individual attributes of trait empathy, musicality and autonomy were included in the analysis as co-variates. The dependant variable of pain was measured in three dimensions, duration on the cold pressor task, pain intensity and pain unpleasantness, to account for the multi-dimensional nature of pain. One-tailed Spearman correlations were used to demonstrate that duration

| Table 2: Music stimuli and familiarity ratings from pilot study |
|------------------|-------------------|-----------------|
| Song title       | Artist            | Familiarity rating |
| Relaxing music   | Sleeping Music    | Deep Sleep Music Collective | 3 3.16 |
| This Isn’t You   | Kyle Dixon        | 2.6 3.21 |
| Danger of Hell   | Thomas Newman     | 2.2 2.68 |
| Motivating Music | Solero            | Sons of Maria | 2.5 2.59 |
| Lighthearted     | Deep Chills       | 1.8 1.3 |
| The Balance      | Moses Boyd        | 1 1.22 |

Note: Relaxing music was defined as music with a low tempo of 60–80 beats per minute, with low levels of arousal and gentle rhythms. Motivating music was defined as music with a high tempo of 100–110 beats per minute, high levels of arousal and danceable rhythms.
change on the cold pressor task was not significantly correlated with pain intensity \( r(312) = -0.28, p > 0.05 \) or pain unpleasantness \( r(312) = -0.09, p > 0.05 \). Similarly pain intensity and pain unpleasantness were only moderately correlated \( r(312) = 0.57, p < 0.001 \), which indicates that each pain measure represents three separate dimensions of pain and so a separate GLMM was conducted for each dimension of pain. Each GLMM was conducted with a link identity function and with participants as a random factor. By including a link function, the model automatically specifies interactions on the natural scale of the linear predictor (Tsai & Gill, 2013), which means the main effects observed rely on the co-variates included in the model, which are listed in Table 4.

4  |  RESULTS

4.1  | Emotional responses to motivating music and relaxing music

A preliminary analysis was conducted to compare mean emotional ratings on the GEMS-9 (Zentner et al., 2008) between motivating music and relaxing music. Motivating music was rated significantly higher in terms of activation, \( t(51) = -14.22, p < 0.001 \), 95% CI \([-1.87, -1.41]\) and power, \( t(51) = -12.87, p < 0.001 \), 95% CI \([-1.59, -1.16]\), whereas relaxing music resulted in significantly higher ratings for peacefulness, \( t(51) = 8.73, p < 0.001 \), 95% CI \([0.86, 1.38]\), nostalgia \( t(51) = 8.96, p < 0.001 \), 95% CI \([0.82, 1.29]\), transcendence, \( t(51) = 5.91, p < 0.001 \), 95% CI \([0.47, 0.95]\), tenderness, \( t(51) = 6.23, p < 0.001 \), 95% CI \([0.53, 1.03]\) and sadness, \( t(51) = 6.0, p < 0.001 \), 95% CI \([0.36, 0.72]\). There was no significant difference in ratings for Wonder or Tension between motivating and relaxing music. Overall, this demonstrates that motivating music led to emotional responses consistent with increases in activation and power, whereas relaxing music led to emotional responses consistent with peacefulness, tenderness and sadness.

4.2  | (H1) Self-selected music from unlimited choice

The first hypothesis asked whether self-selected music has an effect on participants’ pain perception. This was performed to validate the experimental paradigm in this study against previous findings and to examine whether under these laboratory conditions self-selected music would lead to an increase in pain threshold. Paired \( t \) tests were used to compare mean duration, intensity and unpleasantness scores between the baseline task and the self-selected music condition. Participants were able to keep their hand in the ice water for a significantly longer duration while listening to their self-selected music from an unlimited range (\( M = 127.71 \) s, SD = 125.42) compared with no music (\( M = 38.50 \) s, SD = 48.55), \( t(51) = -5.84, p < 0.001 \). There were no significant differences found in pain intensity scores, \( t(51) = 0.87, p > 0.05 \) or pain unpleasantness score, \( t(51) = 0.32, p > 0.05 \), between the self-selected music and no music conditions. Participants were able to keep their hand in the ice water for a significantly longer amount of time and did not experience increases in pain intensity or pain unpleasantness.

4.3  | (Hypothesis 2) Perceived music choice, intramusical features, enjoyment and individual attributes

Next, we explored our second hypothesis, which aimed to identify the degree to which the analgesic benefit of music listening is mediated by (a) cognitive agency or (b) intramusical features, independently from parallel effects related to familiarity or enjoyment. Additionally, the influence of (c) individual attributes (enjoyment, age, trait empathy, musicality and autonomy) on the analgesic effects of music listening were examined in parallel as co-variates included in each GLMM. See Figure 3 for the residual plots of each GLMM.

4.3.1  | Duration on cold pressor task

The first GLMM examined the role of perceived choice and intramusical features on duration on the cold pressor task. The overall model was significant \( F(12, 293) = 6.86; p > 0.001 \). There was a significant effect of perceived choice on duration on the cold pressor task \( F(2, 293) = 3.184; p > 0.05 \). Pairwise comparisons demonstrated that participants had significantly longer duration times on the cold pressor task when they had a perceived choice between four songs compared with a perceived choice between two songs and the no choice condition. No effect was observed of intramusical features on duration on the cold pressor task \( F(1, 307) = 2.31, p > 0.05 \) (See Table 3). The coefficients in Table 4 for each of the individual attributes indicate that increases in individual levels of enjoyment for a song, trait empathy and sophisticated emotional engagement led to significant increases in duration on the cold pressor task. However, it is worth noting that the coefficient for sophisticated emotional engagement was considerably larger than the coefficient for trait empathy or enjoyment; this indicates that sophisticated emotional engagement with music had the largest impact on the model. Overall, this indicates that there was a significant increase in duration when participants had a perceived choice in music selection between four songs compared with the perceived choice between two
This effect increased for individuals with higher levels of emotional sophistication with music, higher levels of trait empathy and when people enjoyed the music.

4.3.2 Pain intensity ratings

The second GLMM examined the role of perceived choice and music features on pain intensity ratings. The overall model was significant $F(12, 293) = 4.85; p > 0.001$. There was a significant effect of perceived choice on duration on the cold pressor task $F(2, 293) = 4.52; p > 0.05$. Pairwise comparisons indicated that participants provided significantly lower ratings for pain intensity when they had a perceived choice between four songs compared with a perceived choice between two songs, $t(1, 293) = −2.64, p < 0.01, SE 1.00, 95% CI [−5.09, −0.74], or when they had no choice $t(1, 293) = p < 0.05, SE 1.01 CI [−4.50, −0.54]$. There was no effect observed of intramusical features on ratings of pain intensity $F(1, 293) = 0.244, p > 0.05$. The coefficients for each of the individual attributes in the GLMM for pain intensity listed in Table 4 indicate that increases in individual levels of enjoyment for a song were related to significant decreases in pain intensity ratings. Overall,
this indicates that there was a significant decrease in pain intensity when participants had a perceived choice between four songs compared with a perceived choice between two songs or had no choice, and this effect was stronger when participants enjoyed the music more.

4.3.3 | Pain unpleasantness ratings

Finally, a third GLMM was conducted to examine the role of perceived choice and music features on pain unpleasantness ratings. The overall model was significant $F(12, 293) = 7.36; p > 0.001$. However, there was no significant effect observed for either perceived choice $F(2, 293) = 1.85; p > 0.05$ or intramusical features $F(1, 293) = 1.36, p > 0.05$ on pain unpleasantness ratings. The coefficients for each of the individual attributes in the GLMM model for pain unpleasantness listed in Table 4 indicate that increases in individual levels of enjoyment for a song, were related to significant decreases in pain unpleasantness ratings. Overall, this indicates that individual preference for a song was the strongest predictor of decreases in pain unpleasantness ratings.

5 | DISCUSSION

To gain a greater understanding of the cognitive mechanisms that mediate the analgesic benefits of music listening, an
experiment was devised to give participants different degrees of perceived control over the music selection, when in fact the music was predetermined by the experimenter. When participants had the perception that they were selecting the music, their pain tolerance increased. Increased perceived control of the music selection was related to increases in duration on the cold pressor task and decreases in pain intensity ratings. This study demonstrates that the reason self-selected music is particularly effective at increasing pain tolerance is partially related to the act of making a choice of the music itself. It is important to note that the effect of cognitive agency was related to the individual attributes of trait empathy, and sophisticated emotional engagement with music and the degree to which people enjoyed the music. This study found no evidence to support the second hypothesis that specific intramusical features mediate the analgesic benefits observed in response to MLIs. Instead, the effect of enjoyment was consistent across all three measures of pain. Specifically, increases in enjoyment were related to increased duration on the cold pressor task, decreases in pain intensity and pain unpleasantness ratings. Finally, one of the key findings is that individual levels of empathy and sophisticated emotional engagement with music contributed to the analgesic effects of music listening. These findings are consistent with predictions made by the cognitive vitality model, which implicates the role of cognitive agency and enjoyment in mediating the analgesic effects of MLIs (Howlin & Rooney, 2020).

Why do increases in perceived control of the music selection increase your pain tolerance? When people are given the opportunity to choose a piece of music, they ultimately become an active participant in the intervention, which inherently makes it a more engaging activity (Fritz, 2017). Selecting a piece of music gives people a greater sense of control over their own actions based on their own thoughts, which directly enhances the individual’s sense of agency (Jeannerod, 2003; Saarikallio et al., 2020). This enhanced sense of agency may help to increase perceived control over pain (Finlay & Anil, 2016) even though the intensity of the pain may not be completely diminished (Mitchell et al., 2008). Music listening has been shown to increase feelings of competence for people with fibromyalgia (Alparslan et al., 2016) and to help rebuild self-identities for people who use music for cancer pain management (Bradt et al., 2015). It seems that in real-world contexts, music listening can help to give patients a sense of mastery in their activities, which can help their self-efficacy and enhance their locus of control (Finlay & Rogers, 2015). In line with the cognitive vitality model, the authors propose that active decision making in MLIs can enhance the individual’s sense of their own cognitive agency, which may activate top-down mechanisms responsible for mediating pain perception.

This study demonstrates that higher levels of sophisticated emotional engagement with music, and trait empathy were predictors of increased duration on the cold pressor task. It seems that individual strategies for music engagement can impact on the effectiveness of music for pain management, as suggested in previous studies (Bradt et al., 2012; Finlay, 2014; Finlay & Rogers, 2015; Mitchell et al., 2007, 2008; Noguchi, 2006). Accordingly, large individual differences in the way individuals perceive and engage with music may explain some of the variance observed across music intervention research (Bradt et al., 2015; Lee, 2016).

In this study, we found a different pattern of emotional responses for motivating music and relaxing music, but this did not seem to make a difference to the analgesic benefit of music. This further emphasizes that the role of making a choice has a greater effect in increasing pain tolerance compared with the role of specific intramusical features. It should be noted that the so-called relaxing music was more likely to elicit sadness responses, which may or may not always be preferred in pain management contexts, depending on the individual (Vuoskoski et al., 2011). Instead, the current study identified that the degree to which people enjoy music is greater predictor of the analgesic benefits of music. This pattern of findings is similar to the previous study that demonstrated that increases in perceived pleasantness was a stronger predictor of increases in pain threshold than intramusical features (Zhao & Chen, 2009). This demonstrates that the type of emotion that people experience in music interventions is not as important as the degree to which people enjoy the music. As mentioned in the Introduction, the importance of enjoyment in music interventions is underpinned by neuroimaging evidence that identified an increase in dopamine release in the mesolimbic pathway in the presence of music for pain management (Dobek et al., 2014). In line with current theories of emotional engagement with music (Juslin & Västfjäll, 2008; Koelsch, 2012), it is most important to consider how people cognitively and emotionally engage with music during music interventions, rather than focusing on the intramusical features or valence of the music.

Participants’ age did not predict any increases in pain tolerance related to music listening. This corresponds with previous findings that music is beneficial for pain management across a range of age groups including children (Nilsson et al., 2009), adolescents (Mitchell et al., 2008; Nagata, 2014), adults (Ottaviani et al., 2012) and older adults (Onieva-Zafría et al., 2013). It seems that music can be used for pain management across a range of age groups; however, the role of agency across different age groups has yet to be established.

This study isolates the role of making a choice in mediating the analgesic benefits of music listening, independently from other contributing factors such as familiarity, personal enjoyment, empathy and musicality (Finlay & Anil, 2016; Garza-Villarreal et al., 2017; Mitchell et al., 2008). Until now, it was not clear that the act of making a choice could contribute to the analgesic effect of MLIs. Given that self-selected
Music has been shown to consistently ameliorate pain more than experimenter-chosen music in clinical settings (Garza-Villarreal et al., 2014; Lee, 2016; Tsai et al., 2014), it is now time to investigate if the act of making a choice also impacts pain tolerance in clinical settings. In addition, when we consider that there was no benefit from any particular type of music and corresponding emotional responses, further research could explore the degree to which the intensity of emotions experienced and the role of aesthetic emotions (Menninghaus et al., 2019) that are related to the analgesic effects of music engagement. The main limitation of this study is that it uses an experimental paradigm to examine a specific type of pain, so it is not yet clear if these findings will generalize to different types of pain in clinical settings. A second limitation of this study is that it did not operationalize pain tolerance on the cold pressor test as time from first pain perception to hand withdrawal. This was deliberate to assess the point at which participants became aware of the pain stimulus rather than how long they could tolerate it, but it should be considered when appraising the reproducibility of the findings. Nonetheless, the experimental method used in this study was a suitable way to isolate the specific role of decision making in mediating the analgesic benefits of MLIs.

Overall, this study provides support for the cognitive vitality model and suggests that the cognitive mechanisms of cognitive agency and enjoyment in mediating the analgesic benefits of MLIs. Although previous studies identified the importance of self-selected music in MLIs (Bradt et al., 2015; Lee, 2016; Mitchell & MacDonald, 2006; Tsai et al., 2014), the current study allows us to identify why. Consistent with previous findings (Garcia & Hand, 2016), the role of intramusical features is insufficient to account for analgesic effects of music listening. Instead, we must consider the role of cognitive agency of the individual when they choose a piece of music and appreciate that the choice itself may in fact change the way in which people engage with the piece of music. When people are involved in the music choice, they become more actively engaged in the MLI, which provide the basis for a greater degree of cognitive and emotional engagement with the piece of music, compared with a passive listening session.

In line with these findings and previous recommendations, people should be given as much control in MLIs as possible to maximize the analgesic benefits (Clark et al., 2006; Finlay & Anil, 2016). In addition, MLIs should be conducted in a way that is enjoyable from the patient's perspective, by providing a suitable time and space for music listening and ensuring that music listening is not interrupted. To further increase the use of music for clinical pain management, practitioners could educate patients on the benefits of music listening and encourage them to listen to their favourite music more regularly, alongside routine care.

CONFlict of interest
The authors declare that they have no competing interests that would conflict with the conduct or outcomes of this study.

AUTHor contribution
All listed authors meet the ICMJE authorship criteria. All authors were involved in the initial concept and design and interpretation of the data analysis. CH was responsible for data collection and analysis. All authors discussed the results and commented on the manuscript, and all authors gave final approval on this version to be published.

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REFerences
Alparslan, G. B., Babadag, B., Ozkaraman, A., Yildiz, P., Musmull, A., & Korkmaz, C. (2016). Effects of music on pain in patients with fibromyalgia. Clinical Rheumatology, 35(5), 1317–1321. https://doi.org/10.1007/s10067-015-3046-3
Bradshaw, D. H., Chapman, C. R., Jacobson, R. C., & Donaldson, G. W. (2012). Effects of music engagement on responses to painful stimulation. The Clinical Journal of Pain, 28(5), 418. https://doi.org/10.1097/AJP.0b013e318236c8ca
Bradt, J., Potvin, N., Kesslick, A., Shim, M., Radl, D., Schriver, E., Gracely, E. J., & Komarnicky-Kocher, L. T. (2015). The impact of music therapy versus music medicine on psychological outcomes and pain in cancer patients: A mixed methods study. Supportive Care in Cancer, 23(5), 1261–1271. https://doi.org/10.1007/s00520-014-2478-7
Clark, M., Isaacks-Downton, G., Wells, N., Redlin-Frazier, S., Eck, C., Hepworth, J. T., & Chakravarthy, B. (2006). Use of preferred music to reduce emotional distress and symptom activity during radiation therapy. Journal of Music Therapy, 43(3), 247–265. https://doi.org/10.1093/jmt/43.3.247
Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. Journal of Personality and Social Psychology, 44(1), 113. https://doi.org/10.1037/0022-3514.44.1.113
Dobek, C. E., Beynon, M. E., Bosma, R. L., & Stroman, P. W. (2014). Music modulation of pain perception and pain-related activity in the brain, brain stem, and spinal cord: A functional magnetic resonance imaging study. Journal of Pain, 15(10), 1057–1068. https://doi.org/10.1016/j.jpain.2014.07.006
Finlay, K. A. (2014). Music-induced analgesia in chronic pain: Efficacy and assessment through a primary-task paradigm. Psychology of Music, 42, 325–346. https://doi.org/10.1177/0305735612471236
Finlay, K. A., & Anil, K. (2016). Passing the time when in pain: Investigating the role of musical valence. Psychomusicology: Music, Mind, and Brain, 26(1), 56. https://doi.org/10.1037/pmu0000119
Finlay, K. A., & Rogers, J. (2015). Maximizing self-care through familiarity: The role of practice effects in enhancing music listening and progressive muscle relaxation for pain management. Psychology of Music, 43, 511–529. https://doi.org/10.1177/0305735613513311
Fritz, T. (2017). Jymmin-the medical potential of musical euphoria. In M. Lesaffre, P. J. Maes & M. Lenman (Eds.), The Routledge companion to embodied music interaction (pp. 278–283). Routledge.

Garcia, R. L., & Hand, C. J. (2016). Analgesic effects of self-chosen music type on cold pressor-induced pain: Motivating vs. relaxing music. Psychology of Music, 44, 967–983. https://doi.org/10.1177/0305736615602144

Garza-Villarreal, E. A., Jiang, Z., Vuust, P., Alcauter, S., Vase, L., Passay, E. H., Cazavos-Rodriguez, R., Brattico, E., Jensen, T. S., & Barrios, F. A. (2015). Music reduces pain and increases resting state fMRI BOLD signal amplitude in the left angular gyrus in fibromyalgia patients. Frontiers in Psychology, 6, 11. https://doi.org/10.3389/fpsyg.2015.01051

Garza-Villarreal, E. A., Pando, V., Vuust, P., & Parsons, C. (2017). Music-induced analgesia in chronic pain conditions: A systematic review and meta-analysis, bioRxiv, 105148.

Garza-Villarreal, E. A., Wilson, A. D., Vase, L., Brattico, E., Barrios, F. A., Jensen, T. S., Romero-Romo, J. I., & Vuust, P. (2014). Music reduces pain and increases functional mobility in fibromyalgia. Frontiers in Psychology, 5, 90. https://doi.org/10.3389/fpsyg.2014.00090

Gold, A., & Clare, A. (2013). An exploration of music listening in chronic pain. Psychology of Music, 41(5), 545–564. https://doi.org/10.1177/0305736612440613

Guétin, S., Giniès, P., Siou, D. K. A., Picot, M.-C., Pommié, C., Guldner, E., Gosp, A.-M., Ostyn, K., Coudeyre, E., & Touchon, J. (2012). The effects of music intervention in the management of chronic pain: A single blind, randomised, controlled trial. The Clinical Journal of Pain, 28, 329–337. https://doi.org/10.1097/AJP.0b013e318282e973

Howlin, C., & Rooney, B. (2020). The cognitive mechanisms in music interventions for pain. A scoping review. Journal of Music Therapy, 57(2), 127–167.

IBM Corp. (2019). IBM SPSS statistics for windows, version 26.0. IBM Corp.

Jeannerod, M. (2003). The mechanism of self-recognition in human. Behavioural Brain Research, 142, 1–15.

Juslin, P. N., & Västfjäll, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. Behavioural and Brain Sciences, 31, 559–575. https://doi.org/10.1017/S0140525X08005293

Koelsch, S. (2012). Brain and music. Wiley-Blackwell.

Lee, J. H. (2016). The effects of music on pain: A meta-analysis. Journal of Music Therapy, 53(4), 430–477.

Linnemann, A., Kappert, M. B., Fischer, S., Doerr, J. M., Strahler, J., & Nater, U. M. (2015). The effects of music listening on pain and stress in the daily life of patients with fibromyalgia syndrome. Frontiers in Human Neuroscience, 9, 434. https://doi.org/10.3389/fnhum.2015.00434

Meninghaus, W., Wagner, V., Wassiliwizky, E., Schindler, I., Hanich, J., Jacobsen, T., & Koelsch, S. (2019). What are aesthetic emotions? Psychological Review, 126(2), 171–195. https://doi.org/10.1037/rev0000135

Mitchell, L. A., & MacDonald, R. A. R. (2006). An experimental investigation of the effects of preferred and relaxing music listening on pain perception. Journal of Music Therapy, 43(4), 295–316. https://doi.org/10.1093/jmt/43.4.295

Mitchell, L. A., MacDonald, R. A. R., & Knussen, C. (2008). An investigation of the effects of music and art on pain perception. Psychology of Aesthetics, Creativity, and the Arts, 2(3), 162–170. https://doi.org/10.1037/1931-3896.2.3.162

Mitchell, L. A., MacDonald, R. A. R., Knussen, C., & Serpell, M. G. (2007). A survey investigation of the effects of music listening on chronic pain. Psychology of Music, 35(1), 37–57. https://doi.org/10.1177/0305736607068887

Mühlensiefen, D., Gingras, B., Musil, J., & Enskär, K. (2009). School-aged children’s experiences of postoperative music medicine on pain, distress, and anxiety. Paediatric Anaesthesia, 19, 1184–1190. https://doi.org/10.1111/j.1460-9592.2009.03180.x

Noguchi, L. K. (2006). The effect of music versus nonmusic on behavioral signs of distress and self-report of pain in pediatric injection patients. Journal of Music Therapy, 43(1), 16–38. https://doi.org/10.1093/jmt/43.1.16

Onieva-Zafra, M. D., Castro-Sánchez, A. M., Matarán-Peñaarrocha, G. A., & Moreno-Lorenzo, C. (2013). Effect of music as nursing intervention for people diagnosed with fibromyalgia. Pain Management Nursing, 14(2), e39–e46. https://doi.org/10.1016/j.pmn.2010.09.004

Ottaviani, S., Bernard, J.-L., Jean-Luc, B., Bardin, T., Thomas, B., Richette, P., & Pascal, R. (2012). Effect of music on anxiety and pain during joint lavage for knee osteoarthritis. Clinical Rheumatology, 31(3), 531–534. https://doi.org/10.1007/s10067-011-1925-9

Rafer, L., Austin, F., Frey, J., Mulvey, C., Vaida, S., & Prozesky, J. (2015). Effects of jazz on postoperative pain and stress in patients undergoing elective hysterectomy. Advances in Mind Body Medicine, 29(1), 6–11.

Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. Journal of Personality and Social Psychology, 57, 1069–1108. https://doi.org/10.1037/0022-3514.57.6.1069

Saarikallio, S. H., Randall, W. M., & Baltazar, M. (2020). Music listening for supporting adolescents’ sense of agency in daily life. Frontiers in Psychology, 10, 2911. https://doi.org/10.3389/fpsyg.2019.02911

Tsai, H. F., Chen, Y. R., Chung, M. H., Liao, Y. M., Chi, M. J., Chang, C. C., & Chou, K. R. (2014). Effectiveness of music intervention in ameliorating cancer patients’ anxiety, depression, pain, and fatigue: A meta-analysis. Cancer Nursing, 37(6), E35–E50. https://doi.org/10.1097/NCC.0000000000000116

Tsai, T. H., & Gill, J. (2013). Interactions in generalized linear models: Theoretical issues and an application to personal vote-earning attributes. Social Sciences, 2(2), 91–113. https://doi.org/10.3390/socsci2020091

Vuoskoski, J. K., Thompson, W. F., McLlwire, D., & Eerola, T. (2011). Who enjoys listening to sad music and why? Music Perception, 29(3), 311–317. https://doi.org/10.1525/mp.2012.29.3.311

Zhao, H., & Chen, A. C. (2009). Both happy and sad melodies modulate tonic human heat pain. The Journal of Pain, 10(9), 953–960. https://doi.org/10.1016/j.jpain.2009.03.006

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