Music and Emotion:
The Intervallic Fallacy of the
Major-Minor Dichotomy

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Personal Statement

Music has been an integral part of my life. I began playing piano when I was two years old and percussion in fourth grade. As I progressed through elementary and middle school, I also developed a deep passion for math. When it came time to choose a research topic for the Al Kalfus Long Island Math Fair in eighth grade, I combined these two passions and investigated the connections between math and music theory. I became fascinated by this connection and continued to research different subtopics of math and music for each subsequent year of the Math Fair, receiving multiple gold medals.

In high school, I began to read academic journal articles, both in my research class and on my own time, about music's benefits on society, and I also grew interested in the intersection of psychology and music. I found it intriguing how music's effects can be so widespread — from improving cognition to treating anxiety and depression. I wanted to perform my own independent research project that would enhance the developments in this field.

However, after reading many articles as well as more popular literature on the subject, I noticed a certain rampant inaccuracy regarding musical intervals and emotion that has been compounded over time. (Specifically, many authors have asserted that music's major-minor dichotomy applies to keys, chords, and intervals. However, the dichotomy is not applicable on the intervallic level.) So, I decided to design a survey that would test this widespread inaccuracy among the literature. Despite the COVID-19 pandemic restrictions, 180 adults from the general population responded to my survey, which was presented online and included embedded audio samples. I completed research both at home and at school. The development of, results from, and conclusions from the survey formed the subject of my Regeneron STS project. My hope has been that this project will lead academics, music therapists, and behavioral scientists to a more accurate understanding of the underlying subject matter, and thus a fuller realization of music's potential psychological and health benefits.

The mathematics required to conduct my project involved two levels. First, I needed to understand equal temperament — Western music's current tuning system based on the twelfth root of two — and how it relates to music's major-minor dichotomy. Fortunately, I was already

acquainted with this knowledge from my previous research for the Math Fair. Second, I had to bolster my familiarity with statistics, including the Student's t-test and p-values. In addition to having taken AP Statistics, I consulted with Professor Harold Sackrowitz, Distinguished Professor and Undergraduate Director of the Department of Statistics at Rutgers University, for aid with the mathematical analysis.

After presenting this project at the Regeneron International Science and Engineering Fair (ISEF) in Atlanta in May 2022 and the inaugural Sigma Xi International Forum on Research Excellence (IFoRE), as well as a paper on music and math at the New York City Electroacoustic Music Festival (NYCEMF), I became motivated to investigate a new aspect of music's major-minor dichotomy for my senior-year research project — music's "open fifth". For this most recent project, I was driven to teach myself as much as I could about the different parametric and nonparametric statistical tests that are available, such as the One-Way ANOVA test (parametric) and the Kruskal-Wallis H test (nonparametric). This new knowledge naturally led me to discover the multiple comparisons problem, a fascinating statistical issue that is still being dealt with today. With a desire to major in statistics in college, I employed significantly more robust statistical methods in this new project. Furthermore, my enrollment in AP Psychology my senior year enabled me to discern greater connections between music and human emotion.

My research experience has solidified my passion for science and math. I am especially drawn to statistics due to its versatility and unusually wide applicability. As the late American statistician John Tukey once said, "The best thing about being a statistician is that you get to play in everyone's backyard."

I would advise other high school students interested in engaging in a research project to prioritize selecting a topic that speaks to their passions and interests. In my case, I was able to create a research project about music — a deep passion of mine, and a subject that is relatively uncommon for a science competition. Rather than focus on what sounds impressive or might win an award, you should try to create a project that is uniquely you.

Abstract

This project aims to expose a widespread inaccuracy in the work of academic researchers regarding how music affects human emotion. A centuries-old musical phenomenon known as the "major-minor dichotomy" refers to the fact that major-key music tends to sound happy while minor-key music tends to sound sad. The dichotomy also applies to major and minor chords, as they form the foundation of the major and minor keys. Unfortunately, researchers typically misunderstand the dichotomy as also applying to the major-third and minor-third intervals that comprise these chords. This mistake impedes the efficacy of studies aimed at determining how music can benefit society, from improving cognition and memory to treating disorders such as depression and anxiety. To test my hypothesis that the dichotomy is inapplicable to intervals, I created a survey in which 180 adult participants listened to six audio samples and reported emotional responses on a Likert scale (from "Definitely Sad" to "Definitely Happy"). The samples, presented in a non-logical order to avoid leading participants, featured each interval alone and within a major and minor chordal context. The participants reported a remarkably high neutral response, and the vast majority of the happy or sad responses lacked confidence. Furthermore, the two intervals alone yielded nearly identical, neutral results while the samples of the intervals presented within a major or minor chordal context yielded responses that reflect the happy-sad duality of those chords. The results support my hypothesis that the major-minor dichotomy on the intervallic level is a fallacy.

Keywords: music, emotion, intervals, triads, major-minor dichotomy

Music and Emotion: The Intervallic Fallacy of the Major-Minor Dichotomy

Psychologists, social scientists, and other researchers, particularly over the past half-century, have endeavored to fully understand the intricate relationship between music and human emotion, aiming to use the fruits of their research to improve lives. Given music's myriad benefits for society and health, it is essential to understand the underlying intersection of music theory and psychology accurately. Unfortunately, an important aspect of music's emotional effects typically gets glossed over, at best, and misrepresented, at worst.

In Western music, it is well established through centuries of empirical evidence that major keys are associated with happiness while minor keys are associated with sadness (Virtala et al., 2010; Parncutt, 2012; Bakker & Martin, 2015). However, the origins of this "major-minor dichotomy" remain elusive (Parncutt, 2014). While major and minor keys as well as major and minor chords (the foundation of the keys) are subject to the major-minor dichotomy, major-third and minor-third intervals are not.

Unfortunately, many scholars and researchers misrepresent this aspect in their discussion of the major-minor dichotomy. Perhaps most notably, in a seminal work published over 60 years ago, renowned British musicologist Deryck Cooke described the major-third as "Concord, natural third: joy" and the minor-third as "Concord, but a 'depression' of natural third: stoic acceptance, tragedy" (Cooke, 1959).

As a more recent example, the authors of "Neurocognition of Major-Minor and Consonance-Dissonance" write, "The dichotomy of major vs. minor is the basis of Western tonal music, present in scales, keys, intervals and chords" (Virtala et al., 2016). They accurately explain how major and minor keys differ in construction and how they elicit happy and sad emotions, respectively. However, the authors are incorrect to identify intervals as being a part of the major-minor dichotomy.

In academia, this inaccuracy has been compounded over decades as new generations of researchers rely on these authoritative works. For example, two prominent works published several decades after Cooke's 1959 article quote his specific descriptions of the emotions of major-third and minor-third intervals (Cardillo, 2008; Costa et al., 2000). A third work asserts, "The interval of a minor third is perceived to convey sadness, whereas the major third is perceived to convey positive affect," in an attempt to paraphrase Cooke's inaccurate analysis (Curtis & Bharucha, 2010). In this way, the intervallic fallacy of the major-minor dichotomy becomes reinforced over time.

This inaccuracy extends beyond academia to numerous articles, blog posts, and other widely available content. For example, in a popular Study.com video on intervals, the narrator proclaims, “Minor intervals tend to sound a little offsetting, dark, or suspenseful... Major intervals tend to sound bright, full, and happy” (Muscato, 2020). As another example, an online excerpt from a book features a table, “Emotional Effects of Intervals,” listing the major-third as associated with “Joy, happiness, brightness” and the minor-third as associated with “Tragedy, sadness” (Chase, 2006). While a preceding note points out that the emotional effect of music depends on other factors, it nevertheless leaves the impression that, absent these other factors, the major-third and minor-third intervals are subject to the major-minor dichotomy.

Correcting this inaccuracy is particularly consequential among academics. As research continues into ways in which music can improve the human condition, progress relies on a proper and complete understanding of the underlying, complicated relationship between music and emotion.

In the following discussion, I will present my survey that supports my hypothesis. I will begin by explaining how musical intervals are formed using semitones and how major-third and minor-third intervals are the building blocks of major and minor chords. I will then discuss why the major-minor dichotomy applies to keys and chords but not to intervals. Finally, I will analyze the survey results while addressing the need for researchers to proceed with accuracy on this subject.

Background

Equal Temperament

In order to discuss intervals, it is important to have a basic understanding of “temperament” (or tuning system), which can be credited with creating the musical intervals we use today. Temperament refers to the system in which the frequencies of each musical note are calculated in relation to each other. There have been numerous tuning systems throughout history. Perhaps the most notable one dates back to Pythagoras circa 500 B.C.E. Using a monochord, Pythagoras discovered pure ratios for the intervals of a scale, including the octave ratio (2:1), the perfect fifth ratio (3:2), and the perfect fourth ratio (4:3). Pythagoras then used these pure ratios to calculate the ratios for the smaller intervals of the scale.

As composers began needing to modulate, or switch keys within a song, there became a need for a new tuning system, as songs did not sound the same in every key under Pythagorean tuning (a musical frustration known as the Pythagorean comma). This is because a tuning system

based on pure ratios that works in every musical key is not mathematically possible. Finally, equal temperament took hold a few centuries ago as a compromise. Under equal temperament, the octave ratio (2:1) is established as the only pure interval. All other intervals are calculated on a logarithmic scale based on the twelfth root of two ($\sqrt[12]{2}$). This produces the semitone (or half-step interval) as the building block of all other musical intervals.

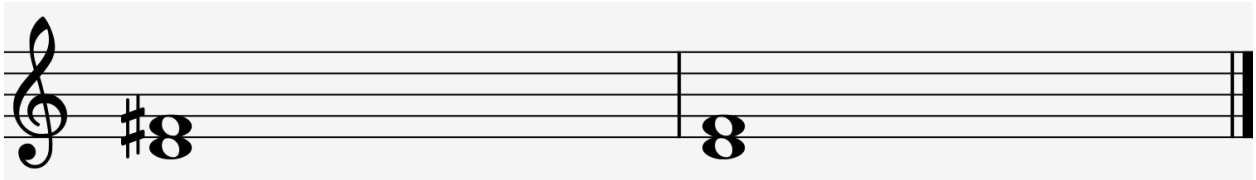
Equal temperament enabled musicians to play music in any key without pitch inconsistencies. Although imperfect in certain ways, equal temperament has nevertheless stood the test of time and operates as Western music's universal tuning system today.

Third Intervals and the Major-Minor Dichotomy

Numerous larger intervals can be formed between two musical notes by adding semitones. The major-third and minor-third intervals, formed by four and three semitones, respectively, hold particular significance because these intervals are the foundation of the major and minor chords (see Figure 1). Major and minor chords are called "triads" because they contain three notes. A major triad thus consists of two intervals: a major-third (from the starting note to the second note) and a minor-third (from the second note to the third note). A minor triad flips the order and consists of a minor-third (from the starting note to the second note) and a major-third (from the second note to the third note).

Figure 1

Major-Third and Minor-Third Interval



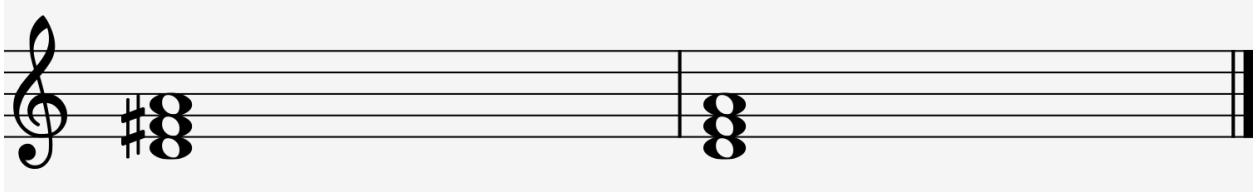
Note. This is an image of a major-third interval (D and F#, left) and a minor-third interval (D and F, right). A major-third interval consists of four semitones while a minor-third interval consists of three semitones. Image created using musescore.com.

Both the major triad and the minor triad, therefore, consist exclusively of a major-third and minor-third interval. They differ only in the order in which these two third intervals are arranged (see Figure 2). Since the sum of the semitones of both intervals is seven (4+3 for a major triad and 3+4 for a minor triad), the larger interval (between the starting and third notes) is the same in both types of triads (and is known as a perfect fifth). Most importantly, this means

that the only difference between a major and minor triad is the second of the three notes, which differs by one semitone.

Figure 2

Major Triad and Minor Triad



Note. This is an image of a major triad (D, F#, and A, left) and a minor triad (D, F, and A, right). The major triad consists of a minor-third interval stacked on top of a major-third interval and the minor triad consists of a major-third interval stacked on top of a minor-third interval. Image created using musescore.com.

This slight difference of a single semitone affecting the second note of a triad has had a monumental impact on music's ability to inspire human emotion. Changing a passage of music or even just a triad from major to minor by lowering the second note (from a major-third to a minor-third interval) has transformed music from a happy to a sad sentiment for centuries. As a result, it is easy to assume that the core of this major-minor dichotomy (and corresponding happy-sad duality) is the major-third versus the minor-third interval. However, the notion that the dichotomy applies on the intervallic level is a fallacy.

While it is true that by lowering the second note of a triad by one semitone, not only does the triad change but the starting interval also changes from major to minor, one must remember that this interval is merely the lower of the two intervals that comprise a triad. As the lower interval switches from a major-third to a minor-third, the upper interval undergoes an opposite switch (from a minor-third to a major-third). This is to compensate so that the larger interval (from the starting note to the third note) remains a perfect fifth. It is critical to remember that both a major-third and a minor-third interval are present in both types of triad; what defines each triad is simply the order in which these two third intervals are stacked.

With that in mind, it follows that listening to a major-third or minor-third interval alone is ambiguous and therefore cannot reliably be a part of the major-minor dichotomy. As with the more obvious case of a single musical note, an interval of two notes still lacks enough musical

data to portray the dichotomy's happy-sad duality. Assuming this to be true, one would expect the following results among typical listeners:

1. A substantial number of listeners would be unable to identify a happy or sad feeling from hearing a major-third or minor-third interval alone.
2. Few listeners would confidently report having felt happy or sad after hearing a major-third or minor-third interval.
3. Listeners would tend to report sadder feelings after hearing either third interval in a minor chordal context as opposed to a major chordal context.

I designed a survey to test my hypothesis that music's major-minor dichotomy applies to keys and chords but not intervals.

Methods

Development of Survey

My survey presents the major-third and minor-third intervals by themselves as well as within a major and minor chordal context. The purpose of the survey was to collect data on participants' emotional response to the intervals played alone and compare their responses to hearing those same intervals featured in the chordal context that is a part of the major-minor dichotomy. I solicited adult participants (18 and older) from the general population (not targeting musicians) through email and social media. In total, 180 eligible participants completed the survey.

Content of Survey and Audio Samples

To test my hypothesis, my survey instructed participants to listen to six musical samples and indicate the emotion each one elicits using a Likert scale. The six samples presented the major-third interval alone, in a major chordal context and in a minor chordal context; then, similarly, the minor-third interval alone, in a major chordal context and in a minor chordal context. The six samples were presented in a different order than this logical progression (as just described) to avoid possibly leading the listener to certain results. However, the questions were presented to all participants in the same order. This was done both for consistency as well as to avoid a situation in which a logical progression is generated at random.

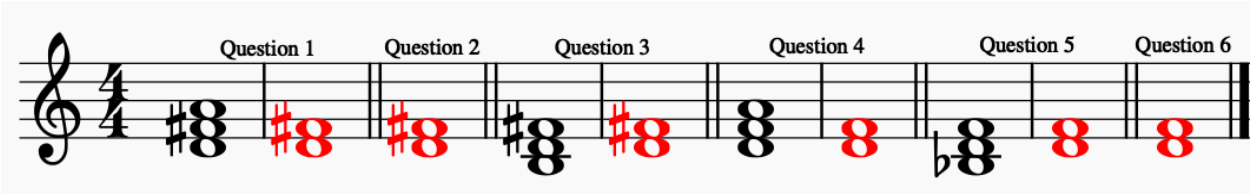
Following a preliminary section requiring age verification and consent, the survey presented six questions asking participants to indicate how happy or sad they felt after listening to each audio sample. To avoid unnecessary musical complexities that could affect the results, the selected intervals begin with the same starting note (D), the music is in the middle pitch

range, the music proceeds at a moderate tempo, and basic instrumentation of a solo piano is used consistently. Since playing an interval is short, each sample was recorded with three identical iterations in succession. This prevented a situation in which participants were unsure how to replay samples or indicated their response without having properly listened to a sample. A local institutional review board deemed the survey (which merely asked participants to read questions and listen to brief audio samples) to be of minimal risk.

Following is a musical representation of the audio samples within the six questions (in the non-logical order, as discussed), with the major-third interval (D and F#) and the minor-third interval (D and F) highlighted in red as the intervals appear in each question (see Figure 3). (Note that in the samples with chordal context, the interval itself is played louder while the chord sounds quietly in the background.)

Figure 3

Music and Emotion Survey – Six Audio Samples (Sheet Music)



Note. This is an image of the six audio samples included in the survey. The major-third interval or minor-third interval of interest is highlighted in red in each example. Image created using musescore.com.

The first three questions presented the major-third interval as follows in Table 1:

Table 1

Music and Emotion Survey: First Three Questions

Question Number	Description
1	Major-third interval (D and F#) within the context of a major triad (D, F#, and A).
2	Major-third interval (D and F#) with no chordal context.
3	Major-third interval (D and F#) within the context of a minor triad (B, D, and F#).

Note. This table is a list of the first three audio samples in the survey, based on the major-third interval.

The final three questions, as seen in Table 2, presented the minor-third interval similarly but in a different order:

Table 2

Music and Emotion Survey: Final Three Questions

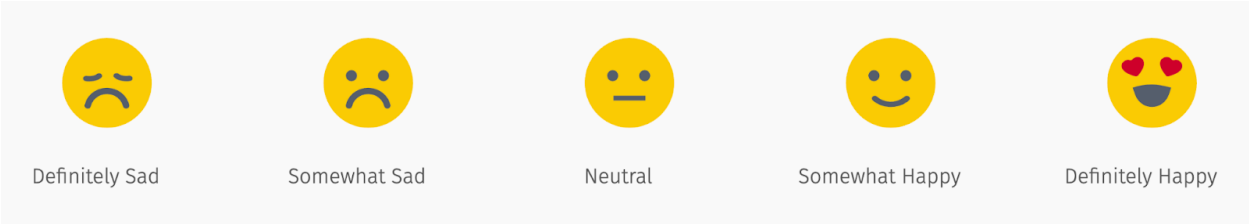
Question Number	Description
4	Minor-third interval (D and F) within the context of a minor triad (D, F, and A).
5	Minor-third interval (D and F) within the context of a major triad (B^b, D, and F).
6	Minor-third interval (D and F) with no chordal context.

Note. This table is a list of the final three audio samples in the survey, based on the minor-third interval.

Participants were instructed to rate the emotion of each audio sample on a Likert scale offering five gradations—*Definitely Sad*, *Somewhat Sad*, *Neutral*, *Somewhat Happy*, and *Definitely Happy* (see Figure 4). The results were then converted numerically to 1, 2, 3, 4, and 5, respectively, for statistical analysis.

Figure 4

QuestionPro Survey – Actual Choices with Images



Results

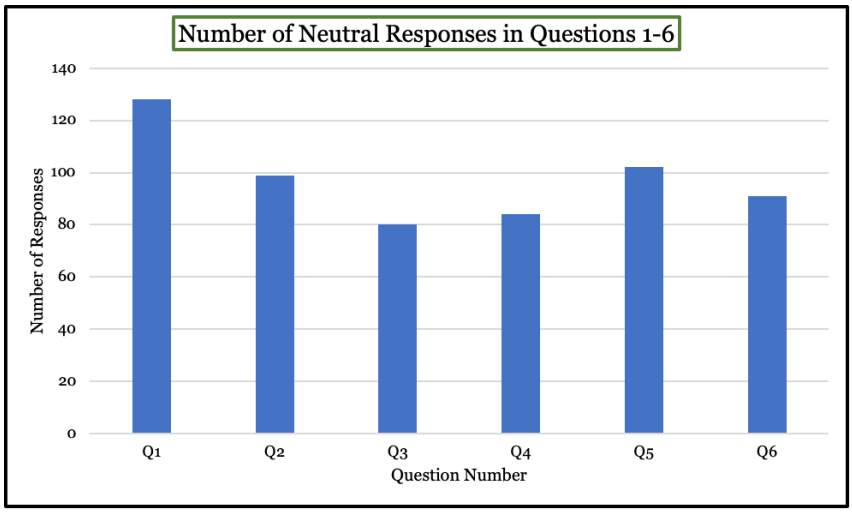
Likert Scale Analysis

High Neutrality

The most striking result of the survey is that the "neutral" response to the audio samples was both high and widespread (see Figure 5). With all six questions, a plurality or majority of the 180 participants were unable to report feeling happy or sad from the sample. The neutrality responses ranged from 44% (Question 3) to 71% (Question 1), with the neutral response in the majority for four of the six questions.

Figure 5

Number of "Neutral" Responses in the Six Audio Sample Questions

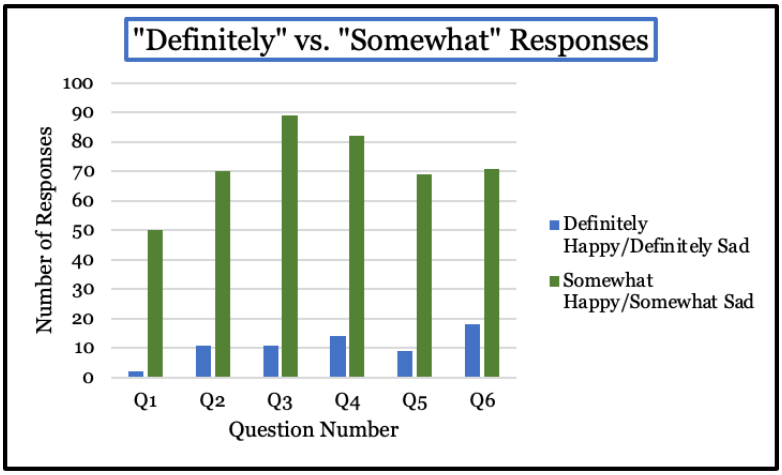


Lack of Definitive Emotional Responses

In addition to the abundance of neutral responses, those participants who reported an emotion almost exclusively did not indicate that they felt it definitively (i.e., respondents mainly answered "somewhat" happy or "somewhat" sad as opposed to "definitely" happy or "definitely" sad) (see Figure 6). More specifically, Question 6 saw the largest number of respondents indicating a definite emotion (10%), and Question 1 saw the lowest number of respondents indicating a definite emotion (1%).

Figure 6

"Definitely" vs. "Somewhat" Happy/Sad Responses



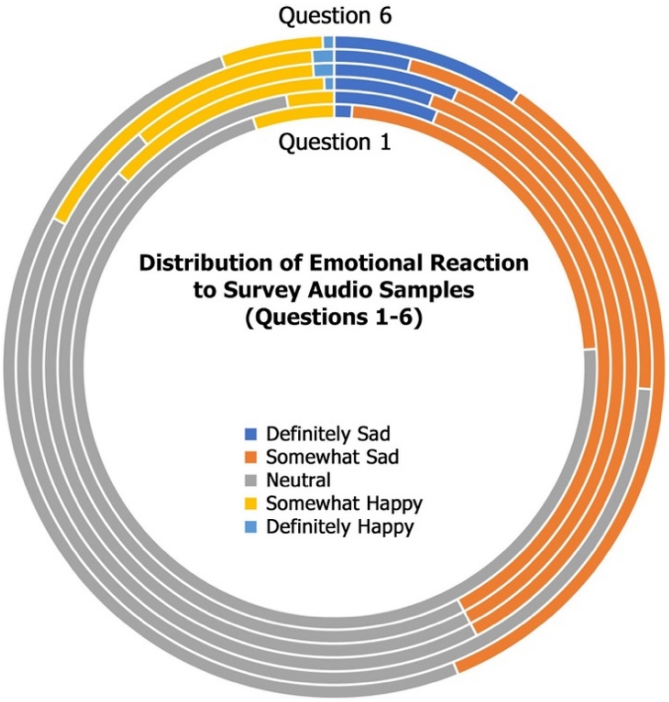
Summary

The combination of the high and widespread neutral responses with the very limited number of "definitely" responses supports the hypothesis that the major-minor dichotomy does not apply on the intervallic level. As indicated by the composite doughnut chart (see Figure 7),

the grey area represents the lack of a reported emotion by participants, and it is the most pervasive. The orange and yellow areas reflect those participants who felt only “somewhat” happy or sad. Only the very small blue areas represent participants who reported feeling an emotional response with confidence (i.e., “definitely” happy or sad).

Figure 7

Audio Sample Questions Results



Note. This is a doughnut chart representing the responses to the six audio samples. Each ring represents the responses to one of the questions, ranging from Question 1 in the inner ring to Question 6 in the outer ring. Image created using Microsoft Excel.

Near-Identical, Neutral Response to Major-Third and Minor-Third Intervals

The major-third interval alone (Question 2) and the minor-third interval alone (Question 6) yielded nearly identical responses despite their contrasting status as major and minor. The mean emotional response for the major-third interval was 2.54 while the mean emotional response for the minor-third interval was 2.53. Since the Likert scale ranges from 1 through 5, both intervals averaged a roughly neutral response.

Paired T-Test Analysis

Major-Third Interval

I then analyzed how participants felt overall upon hearing the major-third and minor-third intervals within a major chordal context versus a minor chordal context. Since major triads and minor triads are subject to the major-minor dichotomy, the expectation is that the emotional response to major-third and minor-third intervals would lean in the happy or sad direction as influenced by the major or minor chordal context, respectively.

I first looked at each participant's emotional rating for Question 1 (the major-third interval in a major chordal context) on the Likert scale and compared it to each participant's emotional rating for Question 3 (the same major-third interval but in a minor chordal context) (see Table 3). The expectation was that participants' rating of Question 1 would be greater (i.e., happier) than their rating of Question 3. I subtracted each individual participant's rating for Question 3 from the same participant's rating for Question 1 and looked to see if the mean of all the differences (Q1-Q3) for each participant was significantly greater than 0.

Table 3

Hypothesis Test 1 – Parameter of Interest, Hypotheses, & Results

Parameter/Hypotheses	
μ_d	True mean difference in emotional rating (Q1-Q3)
Null hypothesis (H_0)	$\mu_d = 0$
Alternative hypothesis (H_a)	$\mu_d > 0$
Results	
t	2.17
p	.016
$\bar{x}$	0.14
S_x	0.86

Note. This table represents the parameter of interest, null and alternative hypotheses, and results for the first paired t-test conducted (regarding the major-third interval). The test statistic, p-value, sample mean, and sample standard deviation are given. Calculations accomplished using Excel.

Since the p-value is less than α (0.05), the results are statistically significant. There is sufficient evidence to reject the null hypothesis and support the claim that the true mean difference in emotional rating (Q1-Q3) is greater than 0. In other words, the evidence suggests that a major-third interval sounds happier when presented in a major chordal context than in a minor chordal context.

Minor-Third Interval

I then performed a similar analysis of each participant's emotional rating for Question 4 (the minor-third interval in a minor chordal context) on the Likert scale compared to each participant's emotional rating for Question 5 (the same minor-third interval but in a major chordal context) (see Table 4). The expectation was that participants' rating of Question 4 would be lower (i.e., sadder) than their rating of Question 5. I subtracted each individual participant's rating for Question 5 from the same participant's rating for Question 4 and looked to see if the mean of all the differences (Q4-Q5) for each respondent was significantly less than 0.

Table 4

Hypothesis Test 2 – Parameter of Interest, Hypotheses, & Results

Parameter/Hypotheses	
μ_d	True mean difference in emotional rating (Q4-Q5)
Null hypothesis (H_0)	$\mu_d = 0$
Alternative hypothesis (H_a)	$\mu_d < 0$
Results	
t	-4.00
p	<.001
$\bar{x}$	-0.25
S_x	0.84

Note. This table represents the parameter of interest, null and alternative hypotheses, and results for the second paired t-test conducted (regarding the minor-third interval). The test statistic, p-value, sample mean, and sample standard deviation are given. Calculations accomplished using Excel.

Since the p-value is less than α (0.05), the results are statistically significant. There is sufficient evidence to reject the null hypothesis and support the claim that the true mean difference in emotional rating (Q4-Q5) is less than 0. In other words, the evidence suggests that a minor-third interval sounds sadder when presented in a minor chordal context than in a major chordal context.

Discussion

The fact that participants were largely unable to discern a happy or sad emotion in any of the six audio samples suggests that the major-third and minor-third intervals themselves are insufficient for eliciting a happy or sad emotional response. In addition, of those participants who reported feeling happy or sad, nearly all of them could not report having definitely felt those

emotions. These two findings, which were consistent among the audio samples in all six questions, reveal a strong lack of confidence in an emotional response on the intervallic level.

In addition, when presented alone, the major-third interval and the minor-third interval yielded nearly identical responses from participants, rather than a sadder response to the minor-third interval. The nearly identical responses (2.54 for the major-third and 2.53 for the minor-third) fall within the neutral range, which suggests a lack of distinction in happy-sad duality when chordal context is absent.

Finally, the hypothesis tests suggest, with statistical significance, that participants felt sadder upon hearing the interval in question under the minor chordal context than under the major chordal context. This phenomenon occurred with both the major-third and minor-third interval. Since the major-minor dichotomy applies to keys and their foundational major and minor triads, the fact that participants' emotional reaction to intervals began to align with the dichotomy once a chordal context was added is further evidence that the dichotomy is inapplicable on the intervallic level.

Conclusion

For decades, academics have inaccurately and widely discussed the major-minor dichotomy as applicable on the intervallic level. However, as this survey has shown, the dichotomy applies only to keys and their foundational chords, and not to the major-third and minor-third intervals that comprise them. This pervasive error relies on a false assumption that a major or minor chord's first interval automatically shares the same emotional character as the chord itself.

If it were true that the major-minor dichotomy applies to major-third and minor-third intervals, a survey would reveal that the vast majority (if not more) of participants confidently reported feeling happy or sad from listening to these intervals alone. However, my survey indicated that participants generally did not feel happy or sad from either the major-third or minor-third interval alone. Despite the name similarity between the intervals and the chords (i.e., "major" and "minor"), these intervals offer musical data that is both too brief and ambiguous to fall under the dichotomy's umbrella. In fact, the Likert scale results were not only neutral but nearly identical for these two intervals, despite their contrasting nature. Moreover, relatively few participants reported feeling "definitely" happy or sad. Finally, participants felt sadder when listening to intervals in a minor chordal context as compared with a major chordal context,

regardless of whether the interval was a major-third or minor-third. This further implies that chords are subject to the major-minor dichotomy while intervals are not.

The close relationship between music and emotion has been recognized for centuries and researchers have advanced ways to improve the human condition in recent decades. Their efforts have led to being better able to use music to prevent or treat depression or other psychological conditions, alter moods, or improve memory or other cognitive functioning. If we are to realize the full potential for progress in this field, our understanding of the underlying subject matter, as with any field, must be accurate. Unfortunately, stemming in large part from the seminal Cooke work of 1959, this small but important aspect of music has been misconstrued. It is not too late, however, to correct this pervasive misunderstanding regarding the extent of music's major-minor dichotomy so that further research into music's potential psychological and cognitive benefits may have the highest chance of producing promising outcomes.

Future Research

The survey supports my hypothesis that music's major-minor dichotomy applies to keys and chords but not intervals. This is true despite the fact that the major triad and the minor triad are both formed by one major-third interval and one minor-third interval. Future research involving a similar survey testing the major-sixth and minor-sixth intervals could prove valuable. These sixth intervals are the inverses of the third intervals because adding a third to a sixth is an octave. Therefore, moving up from any note by a major-third is equivalent to moving down a minor-sixth from the same note one octave higher. For example, ascending from D to F# means moving up a major-third interval while descending from D to (the next lowest) F# means moving down a minor-sixth interval. Similarly, moving up from any note by a minor-third is equivalent to moving down a major-sixth from the octave higher. In other words, ascending from D to F means moving up a minor-third interval while descending from D to (the next lowest) F means moving down a major-sixth interval. Therefore, testing these sixth intervals in the same way as I tested the third intervals should produce similar results. Given this expectation, future research of the major-sixth and minor-sixth intervals would serve to further support the hypothesis.

In addition, an investigation into the open-fifth chord (or perfect-fifth interval) could provide further insight into the major-minor dichotomy and its effects on human emotion. Analogous to how the major-third and minor-third intervals do not provide enough information to enable a listener to discern a specific emotion (due to a lack of a chordal context), the open-fifth chord could produce similar results. Since the open-fifth chord lacks the "middle" note that

would create either a major or minor triad (hence the term "open"), research into how the human mind interprets the open-fifth chord in the context of the major-minor dichotomy is warranted.

Finally, the rationale of why the major-minor dichotomy exists under equal temperament in Western music remains elusive. Although empirical evidence over centuries has established the dichotomy's existence, no researcher has yet established a definitive explanation for this existence. One recent study, for example, explored six leading theories—dissonance, alterity and markedness, uncertainty, speech, salience, and familiarity—and concluded that "there are credible arguments and evidence for and against." The study further noted that "[t]he association between major/minor tonality and positive/negative emotional valence is psychologically robust, but without a single accepted explanation" (Parncutt, 2014). Discovering the reason for the major-minor dichotomy would unlock the door to a greater understanding of the relationship between music and human emotion. This clarity would, in turn, enable even greater advancement by researchers seeking ways to use music to improve cognition and memory and treat disorders such as depression and anxiety.

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Statement Regarding Human Subjects

Research involving non-human vertebrates or human subjects was conducted under the supervision of an experienced teacher or researcher and followed state and federal regulatory guidance applicable to the humane and ethical conduct of such research.

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