# EXAMINING THE EFFECT OF ORAL TRANSMISSION ON FOLKSONGS

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SOCIOLINGUISTS FREQUENTLY EXAMINE THE nature of gradual, internal shifts in languages and dialects over time, arguing for both cognitive and cultural factors, as well as those that might be somehow internal to the language itself. Similarly, musicologists have often argued that musical genres and even specific songs can be examined through gradual diachronic shifts, which seem to be especially accelerated in traditions that rely on oral transmission. For example, Spitzer (1994) examined the stemma of "Oh! Susanna" and noticed that it tended to become more pentatonicized at cadence points by dropping scale degree seven, and suggested that this might be true with folk songs in general. To test this, we employed both experimental and corpus-based paradigms. The experimental approach attempted to simulate oral transmission in a compressed timeframe by involving singers who heard and replicated short musical excerpts, and then would teach a colleague, who in turn passed it on to another participant. Similarly, we conducted a corpus analysis that examined the prevalence of descending stepwise endings in styles of music primarily transmitted orally compared with those transmitted primarily through notation. The experimental results suggest that cadence points in Western folk music are more likely to lose scale degree seven through the act of oral transmission, and the corpus study suggests that, although stylistic constraints play a large role in folk music, there might also be a relationship between transmission and physical affordances.

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THE CLASSIC CHILDREN'S GAME "TELEPHONE" consists of a simple premise: an utterance passed from one observer to the next is likely to undergo some sort of transformation through the simple act of transmission, and a humorous disparity between the original and final statements will result. The study of *how* these statements change, and the constraints that might inform these changes, is crucial not only to our understanding of musical style, but also of musical communication (and communication, in general).

We expect such changes with orally transmitted ideas—we are less likely to have an authoritative reference point—but often a similar situation occurs even with the presence of an authoritative text. In early 18th century New England, for example, the musically literate elite realized that they were unable to preserve much of the melodic materials in compiled editions of music, as the general population began to sing their own variations (see Brooks, 1998, p. 35). Their solution was to educate the population on musical notation, a notion that succeeded in its goal to maintain the authority of the approved text, and to minimize excessive variations.

The effects of "musical telephone," however, persist. Spitzer (1994) examined the effects of transmission on Stephen Foster's "Oh! Susanna," and found that as the notated composition began to be transmitted orally, a number of changes began to occur: rhythmic ideas would gradually align more closely with the beat, the harmonies were changed so that the melodic notes were the root of the chords being used, sections that included varied repeats transformed into literal repeats, and cadence points became somewhat "more pentatonic" (Spitzer, 1994, p. 116); more specifically, $\hat{7}$-$\hat{1}$ motion often transformed into $\hat{2}$-$\hat{1}$ motion.[1]

When divorced from an authoritative text, it seems that musical change follows a similar trajectory to language, in that it constantly undergoes some sort of transformation. To paraphrase Labov (2001, p. 9), the fact that change occurs over time (in either language or music) is one of the few safe assumptions one can make. We might therefore ask, what can these changes tell us about communication, human learning, and music? What exactly are the implications of the leading tones of a melody being consistently replaced by descending stepwise motion at cadence points?

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[1] It could be argued that a melody becoming "more pentatonic" would include the lowering of the leading tone by a semitone ($\hat{7}$ becoming $\flat\hat{7}$), but Spitzer is quite clearly referring to a replacement of "ti" with "re."

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This question has been studied in various capacities in music for quite a while. Sharp (1907) argued for a three-stage process of musical transmission, consisting of continuity, variation, and selection. Continuity was "a passive rather than an active agent; a condition, not a cause" (Sharp, 1907, p. 29), whereas variation was the creative element that led to further musical development. For Sharp, continuity was closely related to the simple passage of time—a perpetuation of an idea already in motion. His analyses of singer Henry Larcombe's improvisations, on the other hand, emphasized the role of variation. The hour-long performance consisted of no exact repetitions, despite the fact that many points were deemed to be identical by the performer. Finally, Sharp's notion of *selection* protected against an over-spawning of musical ideas in favor of a controlled directed shift in musical ideas. There are obvious Darwinian aspects to this line of thinking, perhaps most notably when he writes that, as "in the animal and vegetable worlds, those variations will be preserved, which are of advantage to their possessors in the competition for existence . . . in the evolution of folk-tunes . . . the corresponding principle of selection is the taste of the community. Those tune-variations which appeal to the community will be perpetuated as against those which attract the individual only." (Sharp, 1907, p. 29, as cited in Bronson, 1954, p. 5) Why would some tune-variations appeal to the community whereas others wouldn't? Musical choices are rarely up for a vote, and there must be a reason for certain musical events to be more readily used than others.

Bronson (1954) would later use Sharp's ideas on musical selection as a foundation for his own analysis of folk ballads, invoking what might be best described as a corpus study to examine the similarity of musical ideas amongst folksongs. He found that English and Scottish folksongs differed in their usage of pentatonic and hexatonic collections—Scottish tunes contained far more pentatonic melodies (which Bronson often refers to as "gapped" melodies), with two-thirds of Scottish folk songs being pentatonic and only one-fifth of the English folksongs. He also found that Appalachian folksongs tended to align more closely with Scottish than English melodic styles, perhaps providing some interesting fodder for migration corpus studies in the future. Bronson also discusses a melodic "core of identity," and argues that "plagal melodies" were more "vulnerable to influence" (Bronson, 1954, p. 12) than "authentic melodies," suggesting that musical change is not uniform, and that the selection process not affect all melodies equally. Although he never suggests a possible cause for this, we might argue that plagal melodies are likely more difficult to sing; the fourth scale degree—a defining aspect of a plagal melody—is often among the most difficult pitches for novice singers to sing in tune.

The question of transmission—how things are transmitted and why certain ideas might be more easily lost in transmission than others—is the locus of the entire research area known as social learning, defined as "learning that is influenced by observation of, or interaction with, another animal . . . " (Hoppitt & Laland, 2013). The study of the transmission of ideas could be examined in a controlled setting with many of the methodologies pioneered by the social learning field. For example, Payne and Payne (1985) found that male humpback whales in a certain population all sang a song that would gradually change through the season as various changes were gradually introduced, and Garland et al. (2011) found that migration of humpback whales created a change in song types that followed the migratory patterns.

Perhaps one of the most influential social learning studies that focused on humans was conducted by Bartlett (1932) and involved participants being presented with either text or a picture, recalling it, and having the result of that recall passed to the next participant, who in turn produced their own version of their recollection to another participant. Bartlett concluded that there are always some features ("dominant features") that are more easily maintained than others throughout transmission.[2] This type of methodology is known as a "transmission chain." The simplest form of transmission chain is a linear transmission chain, in which one person directly demonstrates to another.[3] This is also commonly referred to as an "iterated learning paradigm" (see Smith, Brighton, & Kirby, 2003, for an extensive discussion of this paradigm to analyze the evolution of language), and has been used extensively in recent experimental work addressing the impact of transmission on musical structure (Lumaca & Baggio, 2017; MacCallum, Mauch, Burta, & Leroia, 2012; Ravignani, Delgado, & Kirby, 2016). Recent work by Janssen (2018) has examined the role of phrase length, rehearsal, and expectancy on transmission using pattern-discovery methods. Studies examining melodic memory, however, have tended to rely more on recognition, rather than production, paradigms. (see Halpern & Barlett, 2010; Halpern & Bower, 1982; Halpern, Barlett, & Dowling, 1998).

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[2] Kleeman (1985, p. 5) draws the obvious comparison between Bartlett's dominant features and Schenker's notion of an *Urlinie*.

[3] For more on the history and background of such studies see Hoppitt and Laland (2013).

The transmission chain methodology seems particularly appropriate for examining how a musical signal like a melody changes over time, but as with all methodologies it comes with its own set of strengths and weaknesses. A disadvantage to this method is that, as the chain is linear, a single distorted signal can make significant changes. A common approach to this is to run many transmission chains, as we have here, or to employ a diffusion method, as is discussed in the final section of this paper. Additionally, it's not as reflective of musical practice as other methods (such as diffusion) might be. One rarely learns a melody from a single individual. Instead they are presented with multiple versions of the melody from multiple sources.

One benefit of the linear transmission chain approach is the ability to conduct an experiment in a controlled laboratory environment. Although orally transmitted folk melodies change gradually over years through many different forces, a linear chain methodology provides a microcosm of these events within a short and controlled setting.

Another advantage comes from the ability to detect *transmission biases*. In other words, by carefully controlling the stimuli, particular types of changes might be witnessed that can cast light on cognitive or social biases that may play a role in the broader culture. For example, Mesoudi and Whiten (2004) found that participants passed along information with increasing generality, losing more of the specifics throughout the transmission. They argued that information might be processed hierarchically, and that lower-level details are more susceptible to loss and change than the higher-level aspects of information.

Here, we examine the role of the oral transmission of melodies through this linear transmission chain paradigm, attempting to isolate the points of musical change through the process of a series of musical communications. Specifically, we attempt to investigate Spitzer's theory of increasingly pentatonic cadential points. For many reasons, however, we will abstain from looking specifically at pentatonicism. Firstly, pentatonicism is quite broadly defined (as discussed below), and can mean either any collection of only five pitches, or a specific collection of pitches (for example, $\hat{1}$, $\hat{2}$, $\hat{3}$, $\hat{5}$, $\hat{6}$). Van Khe (1977) argues that the pentatonic scale is, to some extent, universal, but each collection discussed is quite different: some include semitones, some include only whole steps, etc. It would therefore seem that a more manageable way of analyzing Spitzer's hypothesis would be to first examine the treatment of the melodic cadence, without making any broad generalizations of pentatonicism.

## Experiment 1: In Search of Changing Penultimate Notes

### METHOD

In order to examine whether or not there are predictable patterns for how penultimate notes change throughout the course of oral transmission, we invoked a linear transmission chain in which participants were presented with a melody (which either contained a $\hat{7}$-$\hat{1}$ or a $\hat{2}$-$\hat{1}$ cadence), and we asked them to sing it to another member of the group (each group had four participants). We hypothesized that $\hat{7}$-$\hat{1}$ cadences were more likely to transform into $\hat{2}$-$\hat{1}$ cadences than the reverse.

*Participants.* Sixty participants were split into groups of four. All participants were music majors, with training in music theory and aural skills. There is a danger that using such participants might bias the sample when looking at the transmission of musical ideas: music has been transmitted for centuries by amateurs, and any "loss of the signal" that might be typically seen in the field might be minimized by training in aural skills and melodic dictation. Also, recall that the solution in early 18th-century New England to the spawning of many melodic ideas through transmission was to provide training in musical notation. It is therefore possible that a population trained in the fundamentals of music might be *less likely* than the general population to stray from the given melody. On the other hand, signal degradation might be too extreme if participants who had no musical inclination were used—it is likely that, historically, those responsible for oral transmission of melodies were more likely to be musicians, even if not formally trained. In the worst case scenario, a participant who is unable to match pitch would break the transmission chain and no meaningful conclusions could be made from the results. We therefore opted for a subject pool consisting of musically-trained individuals. To examine the effect of sophistication on transmission accuracy within this trained population, each participant was asked to complete the Goldsmiths Musical Sophistication Index survey for musical sophistication (Mullensiefen, Gingras, Musil, & Stewart, 2014).

The participants were all music majors at the University of Mary Hardin-Baylor, enrolled in Music Theory 2, 3, or 4. They were first and second year university students (32 F, 28 M; mean age = 19.5; *SD* = 1.7), and 25 were vocal majors. The mean Gold-MSI scores for general musical sophistication was 81.1 (*SD* = 6.2) out of a possible score of 126. The Gold-MSI self-report scores for singing ability were 30.4 (*SD* = 4.0), out of a possible score of 49. The participants reported an average of 1.8 years of formal training in music theory (*SD* = 1.2).

*Stimuli.* A primary motivation in this experiment was to mirror the process of oral transmission as closely as possible. We therefore chose to select existing songs from an oral tradition, in order to ensure that musical materials were as amenable to oral transmission as possible. However, participant familiarity with selected songs could pose a difficulty in distinguishing the pure effects of oral transmission from the effects of memory. To mitigate this issue as much as possible, we elected to choose from an orally transmitted repertoire that would be unfamiliar to our participants. Also, because we are examining oral transmission, we chose to present participants with a recording of each melody, and it was furthermore important to use recordings of a singer who was unaware of our hypothesis, so as not to unconsciously bias the recordings. Finally, because we wanted to isolate the effects of oral transmission on melodic structure, we wanted recordings in which the songs were sung on a neutral syllable.

A suitable corpus that fulfills all of these criteria can be found in Weiss, Trehub, and Schellenberg (2012). This experiment involved "unfamiliar folk melodies from the United Kingdom and Ireland [that] . . . conformed to Western tonality" sung by "an amateur female (alto) singer without lyrics (i.e., "la" for each note) in an everyday (non-operatic) manner" (p. 1075). The melody pitches were altered using Melodyne's (2014) pitch center and pitch drift functions, and some note timings were manually adjusted for temporal accuracy. Weiss et al. (2012) found that these altered melodies were rated as sounding more "natural" than the original recordings, likely as a result of correcting rhythms that were sung out of time (Weiss, personal communication, 2014). Post-experiment interviews in the present experiment confirmed that no participants knew (or were able to name) any of the songs used from this corpus.

Recall that our hypothesis has been constrained to examine only the motion from the penultimate to the final note of each song, and to specifically contrast $\hat{7}$-$\hat{1}$ and $\hat{2}$-$\hat{1}$ motion. More precisely, our hypothesis is that $\hat{7}$-$\hat{1}$ motion will be replaced by $\hat{2}$-$\hat{1}$ motion *more often than* the reverse. For this reason, it was important to balance our sample of folk melodies such that we used equal numbers of final cadence types. From the Weiss et al. (2012) database of 64 folk melodies, 10 were selected. Five of these melodies ended in $\hat{7}$-$\hat{1}$ motion and the other five ended in $\hat{2}$-$\hat{1}$ motion.

Despite our focus on only the final two notes of each melody, it is important to observe that these notes are not isolated from their context. In other words, it is entirely possible that the melodic structure of earlier moments in each melody afford one of the two cadence types over the other. This extra-cadence musical material may exert an influence over the cadence, such that musically trained participants may be inclined by the structure of the melody to use one cadence motion over another. In order to isolate the effect of penultimate approach from its greater melodic context, we created alternate versions of each melody. Specifically, for each melody that ended with $\hat{7}$-$\hat{1}$ motion, we created an alternate version that was exactly the same except for the penultimate note, and vice versa. These alternate versions were created manually using Melodyne's pitch correction tools. However, some of the alterations produced note transitions into the penultimate note that melodies that might be difficult to sing, such as those containing melodic dissonances (augmented and diminished intervals, as well as intervals such as a 7th; see the altered melody in Figure 1). We therefore introduced the final exclusionary criterion that the interval approaching the penultimate note would be a consonant interval in the traditional music-theoretical sense (such as a third, fifth, sixth, or octave), so altered melodies that featured difficult to sing leaps (such as $\hat{4}$-$\hat{7}$-$\hat{1}$) were excluded.

The final collection of excerpts consisted of 16 melodies: eight unaltered melodies, consisting of 4 that ended with $\hat{7}$-$\hat{1}$ motion and 4 that ended with $\hat{2}$-$\hat{1}$ motion; and a parallel set of eight altered melodies that were identical except for the penultimate note. All 16 melodies used in this experiment are provided in Appendix A.

Pilot studies revealed that the entire melody was prohibitively difficult to memorize in a short time. Trying several permutations, one phrase (consisting of four measures) seemed to be an ideal length for each excerpt; it was short enough to permit encoding into short-term memory, but long enough that participants were unable to store every detail of the melody in short-term memory exactly. This mirrors many of the studies in the melodic recognition literature. For example, McAuley, Stevens, and Humphreys (2004) examined the role of familiarity strength on melodic memory, using novel melodies that averaged about 12 notes in length, and familiar melodies that averaged about 16 notes. Our phrases also fell within the 12–16 note range (see also Halpern & Bartlett, 2010, for a discussion of this). Similarly, Dowling and Bartlett (1981) used short melodic sequences of 5 seconds in a melodic recognition paradigm, which is roughly similar to our own melodic stimuli.

The final phrase of each excerpt was used in the experiment, shortened using Pro Tools 10 (2012) and with a 250-ms fade-in added to avoid pops or clicks in the recording. Figure 1 shows a sample melody with the penultimate note altered.
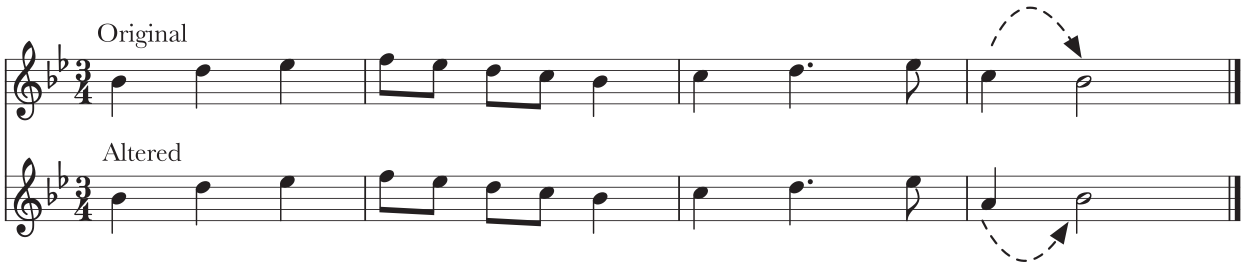
FIGURE 1. The folk melody, "Can Ye Sew Cushions?" is presented in its original form with a $\hat{2}$-$\hat{1}$ ending (above), and in its altered form with a $\hat{7}$-$\hat{1}$ ending (below). The altered form approaches the penultimate with a diminished fifth from 4-7, which is less common and harder to sing, so this melody was excluded.

*Procedure.* Participants signed up in groups of four. Upon arrival they were each given instructions (see Appendix B). Participants were told ahead of time that the experiment would involve singing and being recorded, and were told that they could opt out if they felt uncomfortable. After participants read the instructions, they filled out the Goldsmiths Musical Sophistication Index self-report questionnaire (Müllensiefen et al., 2014). In order to ensure they put forward as much effort as possible, participants were told that the most accurate singer would receive an award.

Because the results of this experiment may be affected by the skill-level of each participant, it was important to balance the design such that each participant would sing first, second, third, and fourth on different melodies. We used a 4 x 4 Latin square for each grouping, in which each iteration of participants was assigned a random order.

For each melody, Participant A remained in the experimenter's office while the other three participants were escorted to a practice room. Participant A then heard the stimulus melody three times, with a pause of 5 seconds in between each hearing. The participant then had the option to practice singing the melody, and then heard the melody a fourth time. While we were careful that participants were not either over-practicing or making too many mistakes for the integrity of the melody to be transmitted, pilot studies indicated that there were floor effects, and that the task was too difficult without practicing at all. We therefore found that a single practice round was one of the most effective means of helping the participants solidify the melody.

After the final hearing, Participant A sang back the melody while the experimenter recorded the performance. Finally, Participant A was escorted to a separate practice room and Participant B was escorted back into the experimenter's office. Participant B then heard Participant A's recording three times, pausing 5 seconds each time, practiced once, then heard it a fourth time, and finally sang back the melody while it was recorded. This continued until Participant D sang the melody back the final time. Participants that had already sung were kept in a separate waiting room from those that had not yet sung. Finally, all four participants were gathered so they could compare the original melody to the final melody. This was primarily done as a way of keeping participants interested, as they were able to hear the mutations that occurred through transmission. See Figure 2 below for a diagram of this transmission chain. This process was repeated for each of the four melodies, using a different order each time. Participants were then brought together to fill out a brief post-experiment questionnaire.

The transcription process was not straightforward. Participants would occasionally sing with hesitancy, and intonation was sometimes a problem. We employed commercial software called ScoreCloud (www.scorecloud.com), which performs monophonic transcription of audio recordings fairly accurately. The recordings were automatically transcribed first, including an estimation of key and meter. These transcriptions

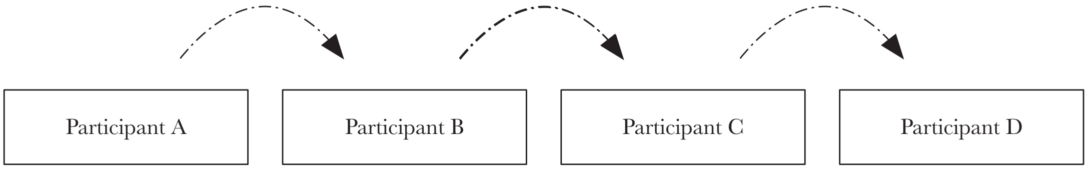

FIGURE 2. Diagram of Linear Transmission Chain.

were then corrected by the authors. The number of total notes in the presented melody were counted, which then became the denominator of a ratio. Every note from this presented melody that was sung in the proper order was added to the numerator, regardless of whether there were intervening notes. Any new notes added to the melody were added to the denominator as well. Put succinctly, a numerator represented the total number of notes a participant got correct, whereas the denominator represented the total number notes the participant could have gotten correct.

## Results

Figure 3 demonstrates a typical round in which a melody is provided in an original recording, followed by the four participants. The third participant in this case alters the $\hat{7}$-$\hat{1}$, introducing a $\hat{2}$-$\hat{1}$ ending. The mean accuracy of singers who did not change the penultimate note from the presented stimulus was 78% ($SD = 20.5\%$, $n = 211$) whereas the mean accuracy of singers who did change the penultimate note was 59.4% ($SD = 27\%$, $n = 29$). Predictably, this difference is significant, $t(32.605) = 3.53$, $p < .001$: the changing of notes (i.e., accuracy) is correlated with the changing of the penultimate note. None of the other covariates in the model were found to be significant. We therefore conclude that neither singer accuracy, individual melody, singer order, nor group accuracy were predictive of a change in the penultimate note.

In order to test the effects of the penultimate note on changes in melody, we employed a mixed-effects logistic regression, in which we examined the specific type of melodic cadence as the factor of interest (i.e., $\hat{7}$-$\hat{1}$ versus $\hat{2}$-$\hat{1}$ endings). Additionally, we included four covariates: singer accuracy, overall group accuracy, and specific melody as random effects, as well as singer order as a fixed effect. In other words, these covariates were taken into account in determining the significance of the independent variable. The results from our regression analysis indicate that the penultimate note presented in a melody was significantly predictive of whether or not the penultimate note would be altered from the recording that the participant heard ß = .23, $df = 1$, $N = 240$, CI = 1.95–10.58, $p < .001$. As beta values are usually only assigned to fixed effects, this coefficient is an average of each slope in the model. We would argue that this estimate might be a bit conservative. Interestingly, although singer accuracy was correlated with the changing of the penultimate note, there was a disparity in how frequently each type of cadence was altered. Out of the 29 recordings in which a penultimate note was changed, 20 of them were originally $\hat{7}$-$\hat{1}$ progressions. These results therefore suggest that, conservatively, melodies that end with $\hat{7}$-$\hat{1}$ motion are 1.09-1.44 times more likely to be transformed into $\hat{2}$-$\hat{1}$ than vice-versa.

## Discussion

The results of our experiment seem to suggest that there is an effect of "$\hat{7}$-$\hat{1}$" endings transforming over time into "$\hat{2}$-$\hat{1}$" endings. The next logical question might therefore be: why is this the case? It could be the case that singing a descending line is physically easier than singing an ascending line. Physiological affordances can definitely contribute to shifts in musical style. Much like statistical learning, physiological affordances can serve to
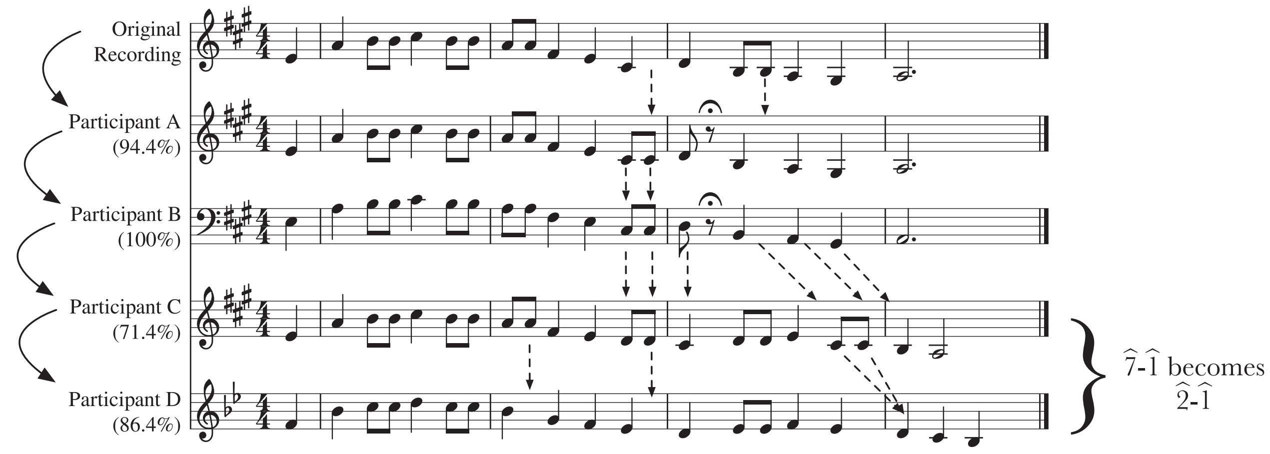
**FIGURE 3.** An example of the transmission of a melody through four participants. The dotted arrows indicate a point at which the melody signal changed.

**TABLE 1.** *A Mixed-effects Logistic Regression Model was Fitted to Examine Predictors of Melodic Change*

| Source | *df* | AIC | BIC | Log likelihood | $\chi^2$ | Chi *df* | *p* |
|---|---|---|---|---|---|---|---|
| Change ~ Original Melody + Singer Accuracy + Singer Order + Penultimate Note (Group Accuracy excluded) | 36 | 181.66 | 306.96 | -54.83 | 9.21 | 14 | .81 |
| Change ~ Group Accuracy + Singer Accuracy + Singer Order + Penultimate Note (Original Melody excluded) | 21 | 162.36 | 235.45 | -60.179 | 10.696 | 15 | .77 |
| Change ~ Group Accuracy + Original Melody + Singer Order + Penultimate Note (Singer accuracy excluded) | 33 | 176.62 | 291.48 | -55.31 | .96 | 3 | .81 |
| Change ~ Original Melody + Group Accuracy + Singer Change + Penultimate Note (Singer Order excluded) | 35 | 180.38 | 302.20 | -55.19 | .715 | 1 | .40 |
| Change ~ Original Melody + Group Accuracy + Singer Change (Penultimate note excluded) | 6 | 152.70 | 173.59 | -70.35 | 6.69 | 1 | .009** |

*Note:* The model with group accuracy, original melody, singer accuracy and singer order was not found to be significantly different than whether or not the melody simply contained a $\hat{7}$-$\hat{1}$ cadential motion. This table examines models with each effect removed, to examine any possible significant predictors. It would therefore appear that the majority of the variance in predicting whether the melody would undergo change in the cadence is accounted for by whether the melody has a $\hat{7}$-$\hat{1}$ or a $\hat{2}$-$\hat{1}$ ending.

minimize elements that deviate from norms. For example, Labov (2001) has studied how North American accents tend to minimize vowel sounds that approach the limits of certain physical abilities, and the outliers become less prevalent over time. Among other reasons for linguistic change, exuding a minimum level of effort and difficulty is one of the most prominent reasons for such shifts (for more, see the Discussion section). We might therefore argue that, if physical affordances lead to more frequent descending cadences, we would be more likely to see such endings in vocal music than in instrumental music. To examine this further, we employed a corpus study approach.

## Experiment 2: A Post hoc Corpus-Informed Analysis of the Penultimate Note

Although Spitzer's original claim focused on the role of increasing pentatonicism (Spitzer, 1994), studying pentatonicism as a consequence of transmission is far from straightforward. As previously mentioned, Van Khe (1977) has discussed the prevalence of the scale across cultures, and has pointed out that five-tone scales in general are by far the most common. It is, however, difficult to understand exactly why the scale is so prominent. Jackendoff (1977) has pointed out that the tones, in fact, do not overlap with the natural overtone series terribly well, a point similarly made by Schenker (1906) regarding the diatonic scale. Day-O'Connell (2007) has actually pointed to melodies becoming *less* pentatonic over time, a theory at odds with Spitzer's. For example, the Lutheran hymn "Ein feste Burg ist unser Gott" succumbed to the pressures of tonality to the point that, by the time Bach set the melody, $\hat{4}$ and $\hat{7}$ were commonly included as passing tones.

A corpus-based approach to defining pentatonicism is therefore quite difficult. As Van Khe (1977) points out, although scales involving five pitches are quite common,

**TABLE 2.** *Percentage of Tunes in Each Database with Five or Fewer Pitches*

| Number of Scale Degrees | B & M ($N = 6{,}210$) | Essen ($N = 6{,}214$) | Meertens Ins. ($N = 1{,}960$) | Meertens Vocal ($N = 4{,}040$) |
|---|---|---|---|---|
| 7-12 | 78.6% | 89.1% | 89.4% | 92.5% |
| 5 | 14.2% | 8.6% | 7.5% | 5.4% |
| 4 | 5.4% | 1.8% | 2.8% | 1.3% |
| 3 | 1.4% | 0.5% | 2.6% | 0.7% |
| 2 | 0.2% | 0% | 0% | 0.04% |
| 1 | 0.06% | 0% | 0% | 0% |

*Note*: The Folksong databases actually contain a higher percentage of pieces with more than five pitches, and the art song dataset (Barlow & Morgenstern, 1948) contains a higher percentage of melodies containing only five pitches.

**TABLE 3.** *A Comparison of Stepwise Endings in the Meertens Vocal, Meertens Instrumental, and Essen Folksong Collection*

| Collection | $\hat{2}$-$\hat{1}$ endings | $\hat{7}$-$\hat{1}$ endings |
|---|---|---|
| Meerten's Vocal | 1087 (75.5%) | 352(24.5%) |
| Meerten's Instrumental | 301 (38.2%) | 489 (61.8%) |
| Essen Folksong Collection | 636 (80.3%) | 156 (19.7%) |

*Note*: For both vocal groups, $\hat{2}$-$\hat{1}$ was significantly more common than $\hat{7}$-$\hat{1}$, but in the instrumental collection, it was reversed.

the specific pitches employed in these scales permit many variations. For example, the Japanese scale "Hirajoshi" consists of 1-2-3-5-6, but the "Ritsu" scale consists of "1-2-4-5-6" (Van Khe, 1977). Therefore, searching by scale degree would likely yield spurious results. Similarly, it's difficult to search by the number of discrete pitch classes, as melodies that we might consider pentatonic often employ non-diatonic pitches, such as passing and neighbor tones. Some pieces even modulate between multiple pentatonic scales, making an algorithmic searching of pitch-classes or pitch-class counts problematic.

An example of some of the difficulties inherent in reifying the pentatonic scale can be seen in Table 2. Given the assumption that orally transmitted musical traditions would be more likely to be limited to pentatonic collections, we would predict that orally transmitted music would contain more works consisting of five or fewer discrete pitch-classes. In comparing amongst four corpora (Table 2, details of each corpus are discussed below), it is clear that there is a predominance of melodies constrained to more than five pitch-classes. However, melodies containing only five notes are not restricted to folksong databases. In fact, as can be seen in Table 2, the art song dataset (the Barlow & Morgenstern collection, 1948) contains a higher percentage of melodies containing only five pitches than the folksong database (the Essen Folksong collection; Schaffrath, 1995).

Rather than trying to operationalize the notion of pentatonicism, it might make more sense (and would be more in line with the experiment) to simply examine final melodic gestures. We hypothesized that there might be a correlation between $\hat{2}$-$\hat{1}$ endings and vocal melodies, as physical affordances would suggest that these would be easier to sing. Although a corpus method can only provide correlational evidence, we would argue that it would be supportive of the overall argument regarding the changing penultimate note as a result of oral transmission. We therefore decided to examine the prevalence of $\hat{2}$-$\hat{1}$ endings compared to $\hat{7}$-$\hat{1}$ endings with matched vocal and instrumental corpora with a corpus-based approach, specifically with the Meertens Dutch Folksong collection (Van Kranenberg, de Bruin, Grijp, & Wiering, 2014). The commonly-used Essen Folksong Collection (Schaffrath, 1995) contains primarily vocal melodies transcribed from 19th-century sources, and it can be difficult to discern instrumental from vocal melodies. Similarly, Barlow and Morgenstern's *A Dictionary of Musical Themes* (1948) is entirely instrumental, and while there are currently efforts to encode the companion vocal set, these themes present melodic ideas based on their salience, and often lack final melodic gestures or cadences. The Meertens collection contains both instrumental and vocal folksongs, making it an ideal dataset for our analysis. In particular, the vocal and instrumental songs are of the same style and represent the same geographic and (roughly) temporal location.

We might then ask, of the instrumental and vocal melodies in the Meerten's Folksong collection, are we more likely to see final gestures ending with a $\hat{2}$-$\hat{1}$ motion or a $\hat{7}$-$\hat{1}$ motion, and would the prevalence of these gestures change depending on whether it was instrumental or vocal music? Of the Dutch folksongs labeled as vocal music ending with stepwise motion to $\hat{1}$, $\hat{2}$-$\hat{1}$ melodic cadences were far more common than $\hat{7}$-$\hat{1}$ cadences, $\chi^2(1, N = 1439) = 375.42, p < .001$ (see Table 3). Conversely, the folksongs labeled as instrumental music contained far more $\hat{7}$-$\hat{1}$ cadences than $\hat{2}$-$\hat{1}$ cadences, $\chi^2(1, N = 790) = 13.41, p < .001$. We also performed a chi-square test on the 2 x 2 contingency table (Table 3) to examine not only the effect between melodic endings but also between corpora (vocal and instrumental). After correcting for multiple tests, this, too, demonstrates a significant difference between corpora and ending types, $\chi^2(1) = 302.65, p < .001$. We additionally examined the Essen folksong collection (Schaffrath, 1995), which consists primarily of vocal

**TABLE 4.** *A Comparison of Motion to $\hat{1}$ Between the Meerten's Vocal and Instrumental Collections, as Well as the Essen Folksong Collection*

| Approach to 1 | 1 | ♭2 | 2 | ♭3 | 3 | 4 | 5 | 6 | ♭6 | ♭7 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Meertens (vocal) | 22.5%<br>(757) | 0 | 46.3%<br>(1558) | 0.6%<br>(19) | 6.2%<br>(208) | 0.1%<br>(4) | 9.6%<br>(324) | 0.06%<br>(2) | 0.03%<br>(1) | 0.4%<br>(14) | 14.2%<br>(479) |
| Meertens (inst) | 49%<br>(806) | 0 | 18.2%<br>(300) | 0.9%<br>(15) | 3.6%<br>(59) | 0 | 2.6%<br>(43) | 0 | 0 | 0.1%<br>(2) | 25.5%<br>(419) |
| Essen | 7.6%<br>(346) | .3%<br>(13) | 56.4%<br>(2579) | 2.3%<br>(37) | 4.6%<br>(210) | 0.2%<br>(7) | 4.6%<br>(208) | 0.2%<br>(9) | 0 | 0.5%<br>(25) | 24.9%<br>(1135) |

works, and found that $\hat{2}$-$\hat{1}$ endings were again far more common than $\hat{7}$-$\hat{1}$ endings (see Table 4).

It seems that much of these results might best be explained by the principle of least effort (or the "Motor Constraint Hypothesis" presented by Tierney, Russo, & Patel, 2011). Descending melodic endings might always simply be preferred to ascending melodic endings. To further explore this in a more cross-cultural context, we examined the Densmore Corpus of Native American Music (Shanahan & Shanahan, 2014). After removing all repeated perfect unisons (a very common ending, occurring in more than 75% of melodies), we find that the final melodic *interval* is more likely to be descending than to be ascending (1146 descending/429 ascending), and this difference is once again significant, $\chi^2(1, N = 1575) = 326.4, p < .0001$.

An analysis of multiple corpora would seem to indicate that descending motion is far more common than ascending motion at the point of a melodic cadence (see Figure 4). This aligns closely with what others have written about the cross-cultural aspects of melodic shape and contour (see Huron, 2006; Savage, Tierney, & Patel, 2017). It therefore comes as no surprise that final resting points are far more likely to be approached through $\hat{2}$-$\hat{1}$ motion than $\hat{7}$-$\hat{1}$ motion. Interestingly, when physiological constraints are less of a factor (as in the case of instrumental folksongs) the tendency seems to be reversed, and $\hat{7}$-$\hat{1}$ seems to be more common. We briefly tested this further by looking at the percentage of descending two-note relationships in the final segments of a song. We examined the final 2–10 notes from the Meertens collection of both instrumental ($N = 4830$) and vocal ($N = 4120$) Dutch folksongs. As can be seen in Figure 5, vocal melodies do contain a higher percentage of descending intervals than instrumental folksongs. The broader trend of increasing usage of descending intervals toward the end of the phrase supports the notion of an "arch-shape" melodic prototype (Huron, 1996), but the increased disparity in the final cadence points might point to a cause that is perhaps more stylistically informed.

## Conclusion

In his 1989 work *Style and Music*, Leonard Meyer defines musical style as "a replication of patterning, whether in human behavior or in the artifacts produced by human behavior, that results from a series of choices made within some set of constraints" (p. 3). These can be stylistic constraints, which are fairly easily learned and adaptable (see Castellano, Bharucha, & Krumhansl, 1984; Krumhansl, 2000; Loui, Wessel, & Kam, 2010), as well as physical constraints, which are more immutable, and can inform musical choices based on "the path of least resistance" (see Huron, 1996; Savage et al., 2017; Shanahan & Huron, 2011). The arch-shape mentioned as a result of physical affordances (see Huron, 1996) might cause descending pitch contours (such as $\hat{2}$-$\hat{1}$) to be more likely to fall within an individual's vocal range than a $\hat{7}$-$\hat{1}$ motion. Future work will explicate the effect of overtly arch-shaped melodies and the changing of a penultimate note.

Much of this conforms to what linguists often refer to as the "principle of least effort" (Bloomfield, 1933; Jespersen, 1921/2013). Labov defines this principle by stating that, "[w]e speak with the least effort that is required to be understood by our addressees, but with sufficient effort to ensure that we are understood" (Labov, 2001, p. 17). One of the best examples of the "principle of least effort" might be seen in the nearly-ubiquitous tendency of pitch to decline over the course of an utterance. As a phrase progresses, speakers lose air from the lungs, and the subglottal pressure decreases, leading to an overall declination in pitch (see Collier, 1975; Cohen, Collier, & t'Hart, 1990). While it has been argued that this phenomenon is more common in prepared speech than spontaneous speech, and is less frequent in interrogative statements (see Umeda, 1982, and Thorsen, 1980, respectively), Hauser and Fowler (1992) found that nonhuman primates also exhibit a declination in pitch over the course of utterances, further pointing to a physiological origin. There is, however, a chicken-and-egg problem with this argument: are descending lines easier to sing because they're more

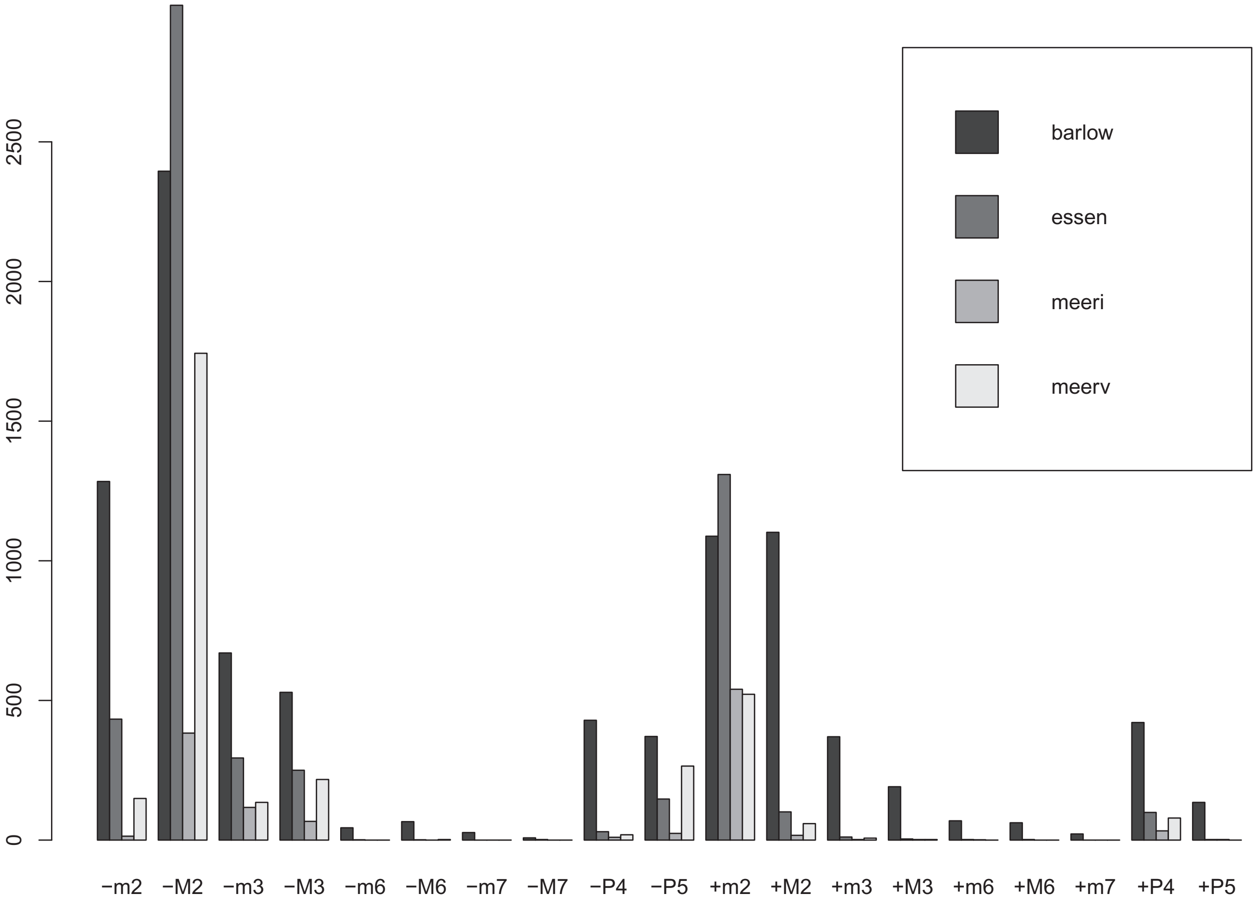

**FIGURE 4.** Count data of ending intervals by corpus. Note that the Meerten's Vocal collection has far more descending Major 2nd endings than the Meerten's Instrumental collection, but that this is reversed for ascending minor seconds.

common, or are they more common because they're easier to sing? This question is beyond the scope of the current experiment, but we hope that, by addressing the nature of affordances throughout transmission, future work might be able to employ experimental paradigms that can disentangle the directions of causality.

When examining gradual changes to a musical signal that are introduced through oral transmission, therefore, it seems appropriate to consider the role that both implicit grammars and physical affordances may play in transforming a signal, and the way these two forces may interact with one another. In the first instance, oral transmission relies on the memory of performers, which is mediated by their understanding of the musical grammar of that music. It therefore seems likely that changes would be introduced that reflect the statistical properties of that music. In other words, it could be argued that whatever deviations are introduced to musical signals through oral transmission are likely to converge on those musical gestures that are most commonly representative of that style. Gradually, musical choices that are less common or that do not conform to predictable or stylistically common tendencies will tend to be replaced with more "syntactically-correct" choices. It is even possible that stylistic syntax may influence the physical ease of producing particular musical licks in an analogous way that particular sequences of muscle movements become learned by athletes as they practice and become easier and more automatic for them to perform.

While musical style might be contingent upon implicitly learned grammars, the embodied physicality of making music also constrains what is possible or common in a musical style. Physiological affordances can contribute to the shifts in musical style in a similar process to that of implicit enculturation. Much like statistical learning, physiological elements can serve to minimize aspects of a musical style that deviate from norms. For example, Labov has studied how North American accents tend to

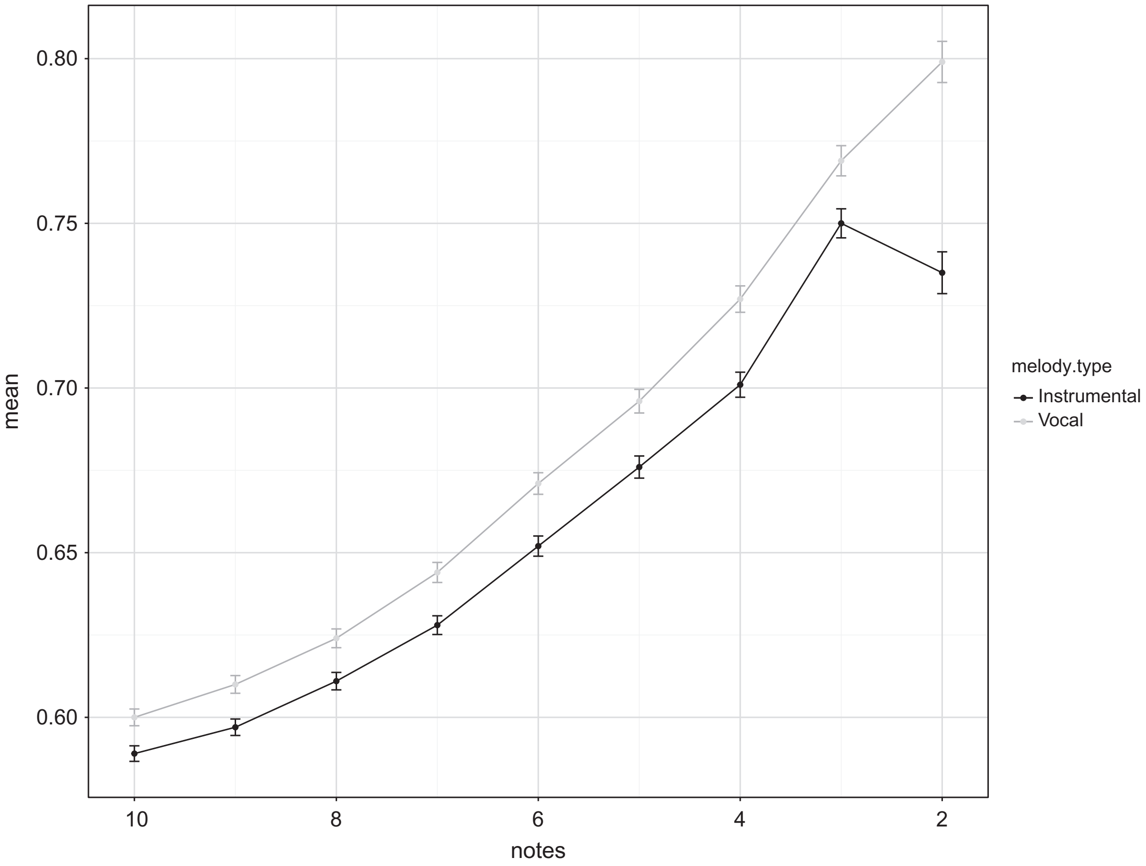

**FIGURE 5.** The average number of descending intervals in the final notes of a song, ranging from the last 10 notes of a song to the last 2 notes, taken from the Meertens Dutch Folksong collection of vocal ($N = 4120$) and instrumental tunes ($N = 4830$). Note that the vocal songs contain significantly more descending intervals than ascending intervals, supporting the notion that affordances play a role in the intervallic content. The broader trend of increasing usage of descending intervals toward the end of the phrase supports the notion of an "arch-shape" melodic prototype (Huron, 1996), but the increased disparity in the final cadence points might point to something more stylistically informed.

minimize vowel sounds that approach the limits of certain physical abilities, and the outliers become less prevalent over time (2001, p. 488). Among other reasons for linguistic change, exuding a minimum level of effort and difficulty is one of the most prominent reasons for such shifts. It can therefore be very difficult to disentangle the way that the two forces of statistical learning and physical affordances individually contribute to musical style due to the feedback loop in which they commonly reinforce one another. Although our experiment was not designed as a critical test of these two theories, we intend to follow up this question in future work.

Our experiment attempted a small-scale replication of the chain of events that might lead to such deviations in musical gestures. As participants would make mistakes, replacing $\hat{7}$-$\hat{1}$ final endings with $\hat{2}$-$\hat{1}$ was far more common than the converse, and it seems that vocal music is far more likely to contain $\hat{2}$-$\hat{1}$ endings than $\hat{7}$-$\hat{1}$ endings, whereas when the physical constraint is different (in instrumental music), melodies are far more likely to end with a $\hat{7}$-$\hat{1}$ ending. This seems to suggest that, although stylistic constraints play a large role in folk music, and can inform how transmission occurs, physical constraints are also likely to inform deviations in a musical idea.

Future work will examine how the transmission chain differs depending on instrumental as opposed to vocal music, and will attempt to isolate more specific physical affordances. Additionally, it might be worth examining how feasible more complex transmission chains might be in an experimental setting. For example, Experiment 1 used a linear transmission chain, in which one demonstrator conveyed information to one observer, but it is possible that a model that allows for multiple demonstrators to convey the same information to an observer, such as a replacement transmission chain, or a diffusion model (see, Hoppitt & Laland, 2013) could be more ecologically valid. Nevertheless, Spitzer's claim that melodies would increasingly contain $\hat{2}$-$\hat{1}$ cadence points over time seems to make sense. Listeners are more likely to sing notes that are easier to sing, and this cadential formula is likely to provide just that.

## Author Note

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## Appendix A
## Sixteen Melodies Used in Experiment 1

### ORIGINAL $\hat{2}$-$\hat{1}$ MELODIES

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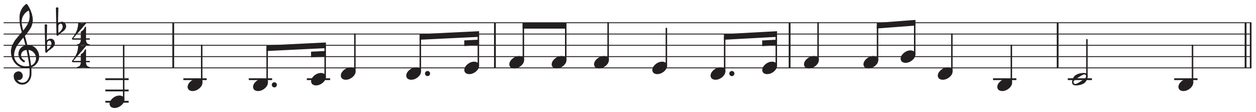
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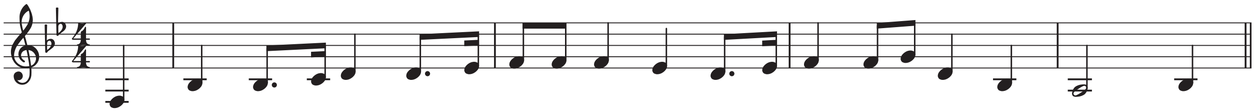
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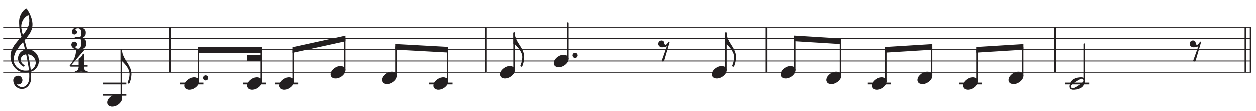

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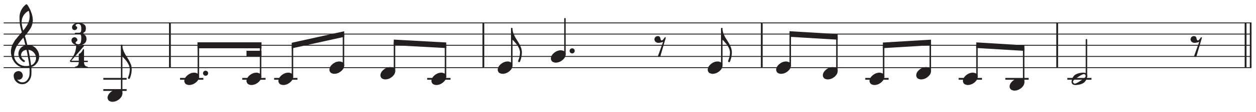
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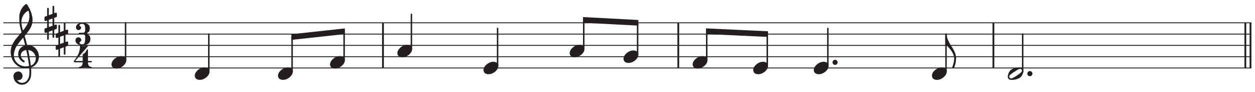

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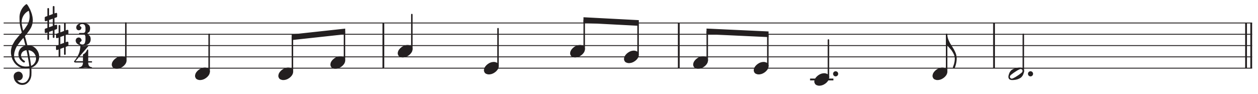
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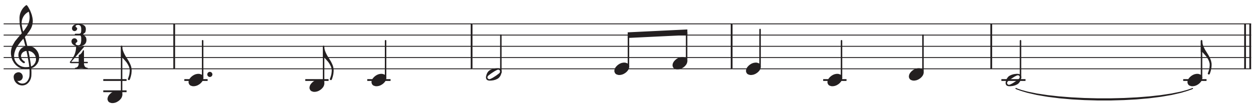

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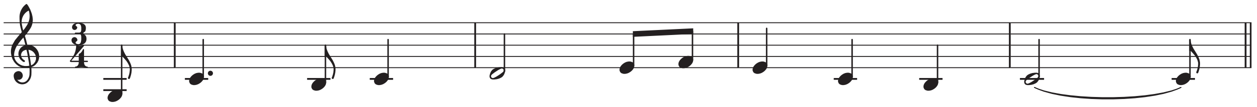
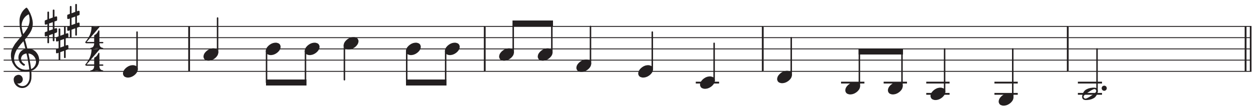


### ORIGINAL $\hat{7}$-$\hat{1}$ MELODIES

5, original



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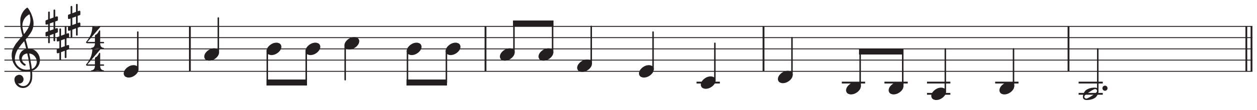

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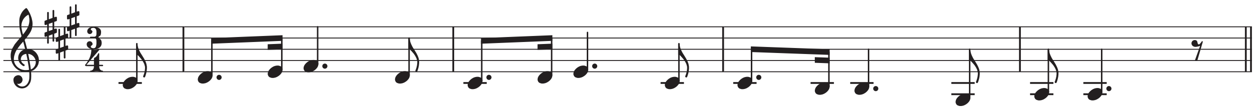

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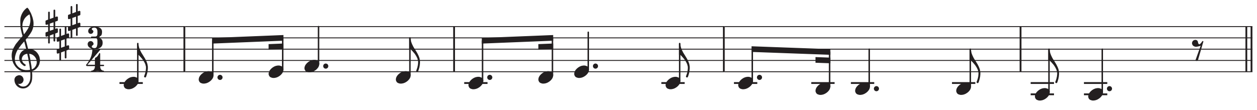

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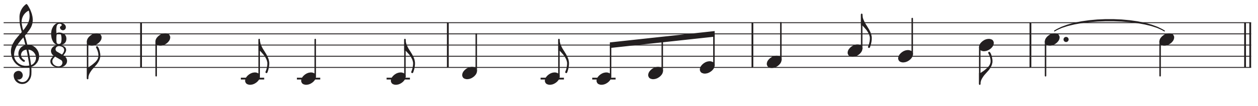

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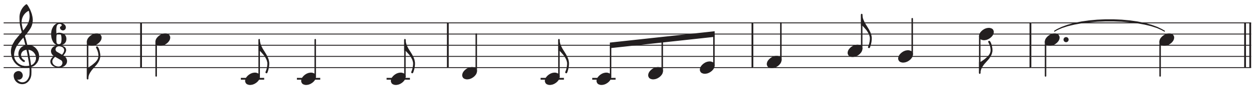

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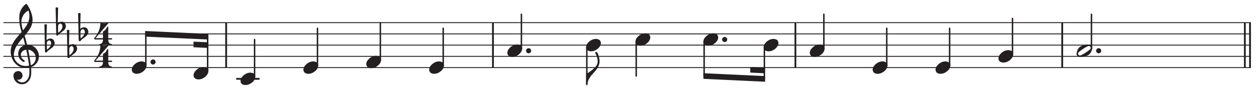
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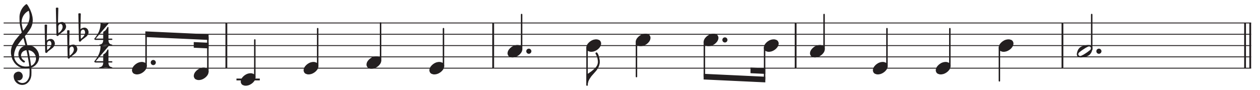
## Appendix B
## Instructions

The purpose of this study is to gather information about how music is transmitted orally. At the end of the experiment, I'll say more about my specific goals.

In this study, we will be playing a game of "musical telephone." First, we will randomly select orders for you for the game. In other words, one of you will randomly be chosen to go first, one randomly chosen to go second, etc.

After selecting your order, the first person will stay with me while the rest go to a practice room down the hall. The first person will hear a recording of a short musical excerpt three times, practice singing it once, hear it a fourth time, and then sing it back to me once while I record the performance. I will then accompany the first person to a different practice room and then retrieve the second person from the other practice room. Once back in my office, the second person will listen to a recording of the first person three times, practice singing it, hear it once more, and then sing it back to me once while I record again.

This pattern will continue until the last person sings the melody while I record. At that point, the other three people will be brought back into my office. The original recording will then be played followed by the final recording, so you can all hear how the melody has been modified, if at all.

For this study, please do not sing any of the melodies outside of my office.

New random orders will be assigned to each person, and the process will be done for a second melody. There will be a total of four melodies.

Throughout this process, I will be recording every melody sung by every person, so I can better track how the melodies change over time.

If singing in this kind of experiment makes you uncomfortable, please let me know now and we can find a different experiment for you to participate in.