Transformations of Tonality: A Longitudinal Study of Yodeling in the Muotatal Valley, Central Switzerland

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THIS study examines the transformations of tonalities in the Central Switzerland valley of Muotatal, a small region attracting the focus of ethnomusicologists for harboring and conserving a unique style of yodel, called *juuz*.[1] Conducting a longitudinal study, three samples of field recordings are compared, collected by Sichardt (sample 1, 1936), Zemp (sample 2, 1979), and Wey (sample 3, 2017).[2] Changes in tonal systems are inherently difficult to observe, as they progress slowly over generations and require audio recordings confined to a specific cultural area. The datasets used in this study nonetheless promise to overcome these difficulties and enable relevant findings for two reasons: First, the recordings were made in the same small community, which is harboring a distinct style of Alpine yodeling. Second, they span multiple generations, and the three samples were obtained at intervals of roughly 40 years.

Introduction: The Narrative on Tonalities of Traditional Singing in the Alpine Region

In recent years, ethnomusicological research in the German-speaking Alpine region has focused on tonalities other than the 12-tone equal-tempered system (Fehlmann 2012, Zemp 2015, Wey 2019), a thrust that cannot be taken for granted. While differing tonal systems were assumed and documented in other parts of the world for many decades, their existence in today's Central Europe is not self-evident. It may be stated without overgeneralizing that the 12-tone equal-tempered system today constitutes the norm in both written and oral musical traditions of the Alpine region, while non-equal-tempered pitch systems are generally perceived as deviations. Traditional music of the Alpine region today moves in major and, rarely, in minor keys. However, there is no clarity as to how far back in history this tonal standardization reaches.

German-language literature on Alpine folk music offers a narrative about the development of tonal systems, assuming that different, regional tonalities were superseded by 12-tone equal temperament during the nineteenth century. This assumption is hereby referred to as a narrative instead of a theory because the grounds it stands on are anecdotal rather than empirical. Audio recordings including traditional songs of the Alpine region emerge later—the earliest preserved recording of a yodel dates back to the turn of the twentieth century—yet

1. This article is an expansion of a paper presented at the 2018 Conference on Analytical Approaches to World Music, held in Thessaloniki.
2. The dataset used for this study is available here.

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contemporary forms of yodeling are probably rooted in developments throughout the nineteenth century (Wey 2019, 115).

Before the 1900s, only anecdotal evidence based on a number of narrative accounts in the form of writings by musically sophisticated travelers can be provided. Those travelers, usually members of the neighboring countries' nobility and bourgeoisie, wrote letters and travelogues detailing their encounters with Swiss folk music. One of these accounts was written in 1860 by the German composer Louis Spohr, who described listening to a group of local singers whose tuning resembled that of a brass instrument (Spohr 1860, 257). Spohr's observation can be interpreted as referring to use of the harmonic series in singing, mimicking the overtones of a trumpet or a horn without valves. The hypothesis that singing outside art music used a tonal repertoire organized by the harmonic series is supported by further arguments: The best known traditional instrument of Switzerland is the alphorn, a natural trumpet which can only produce different notes by overblowing. It is therefore restricted to the notes of the harmonic series. Consequently, the idea of tonality being dependent on the harmonic series before the aforementioned transformation remains important. As British musicologist and alphorn player Frances Jones wrote in her dissertation on alphorn music:

> Even today, Swiss yodel also uses the tuning of the natural harmonics of the alphorn, including notes that are conspicuously "out of tune" in comparison to any version of modern Western temperament. This tuning based on the natural harmonics has been retained because most Swiss yodel repertoire exists solely in the aural tradition and has not undergone the process of being adjusted to fit notation and subsequently been learned afresh from that. (Jones 2014, xix)

This narrative about the development towards today's tonality can be put into a broader social context: transcription and the written dissemination of vocal music in schools, church choirs, as well as other institutions presumably led to a decline and, eventually, to the disappearance of tonalities which relied on oral tradition. Since the relevant changes took place in the nineteenth century, they cannot be documented with the help of sound recordings. The evidence is again restricted to anecdotal reports such as those mentioned above.

The characteristics of defunct, regionally, or locally anchored tonalities thus remain speculative, based on later considerations and historical sources, since sound recording techniques only became available after these tonal transformations were supposedly completed. In contrast, due to the rapid spread of various sound recording devices, later music-aesthetical developments in the twentieth century are comprehensible through sound analysis.

Although not yet systematically studied in relation to the Alpine region, transformations of tonality in connection with the spread of the diatonic system have already been questioned by musicologists in relation to other regions of the world. For example, in his monograph on polyphonic singing in the Pyrenees region of Gascogne, French ethnomusicologist Jean-Jacques Castéret (2012, 81) suggested that the major scale may have replaced older pentatonic scales based on the overtone series. In many regions of the world, the diatonic system with twelve approximately equal semitones can be considered part of the colonial cultural heritage: Kofi Agawu described tonality in a lecture (Agawu 2009) and in an article published years later (Agawu 2016) as a "colonizing force" in African music and proposed the study of tonal systems as a decolonizing strategy. Agawu (2016, 334) states that the nowadays ubiquitous I–IV–V harmonic chord progression, which was spread by Europeans mostly through four-part music in church choirs, has overwritten the indigenous tonal systems in various African cultures. Ethnomusicologist Timothy Taylor (2007, 25) even constructs a symbolic connection between tonality and colonization when he postulates that the spatial division of music into (tonal) centers and peripheral pitch classes corresponds to the same process in geographical and political cartography.[3]

In the Alpine region, a superposition of traditional tonal systems with the norms of four-part choral writing took place, in which the impact of tonal norms on regional traditions might have been similar to that of tonality imported by the colonial powers—though the circumstances of (de)colonization obviously cannot be simply transferred to conditions in Central Europe, and the comparison must be used with caution. In the case of the Alpine region, the main factor propelling this transformation was supposedly the spread of four-part choral singing, which started in the 1820s and progressed throughout the century. In the same time period, compulsory school education was implemented for children of all ranks of society, and singing became part of the curriculum (Wey 2019, 84).

Consequences of this development had a detrimental effect on tonalities which differed from the conventions of art music: Singing outside the equal-tempered system was perceived as off pitch, as "false" or "uncultivated" ways of singing. According to Ringli (2006, 42; translated from the German by the author): "The natural yodel with its tensions and sharpness was increasingly dismissed as wrong and uncultivated, not least because it could not be grasped with the evaluation categories of the judges of the yodeling festivals, but also because it could hardly be learned by people who had not grown up in its tradition." In a similar fashion, Zemp (2015, 63) explains that "the neutral is not allowed in the 'cultivated' singing promoted by the *Swiss Yodelling Association*. It is, therefore, not surprising that the Muotathal yodel choir sings major thirds." However, in more recent times this stigma has been reduced. The driving forces behind this renewed interest in differing tonalities and the acceptance for this range of tonalities remain unclear.

3. "Admittedly, there were at first many tonalities, many local variants or dialects. But tonality as the now-familiar system did prevail in western Europe by the early eighteenth century among composers of art music. . . . I argue that tonality arose to a long supremacy in western European music in part because it facilitated a concept of spatialization in music that provided for centers and margins, both geographically and psychologically" (Taylor 2007, 25).

Muotatal Yodeling: State of Research and Recordings

Muotatal, a valley named after the river Muota, is about 70 square miles wide and, as of 2018, home to approximately 4,000 residents. Example 1 shows the location of the Muotatal valley on a map of Switzerland. No trade routes or travel-ways lead though the valley, which is why traffic from outside the valley used to be—and still is—relatively rare.

The local yodeling style of Muotatal, *juuz*, distinguishes itself particularly from the conventions of written music in traditional singing styles of the Alpine area. It remains transmitted and memorized orally. The earliest comprehensive account of *juuz* stems from fieldwork carried out by Sichardt in 1936.[4] At that time, when the first recordings in Muotatal were collected, the music in this valley was still largely independent and the musical exchange with other regions and genres was very limited. Music was usually performed and listened to live, while surrounding regions were already saturated with industrially produced music adapted for national or international audiences. Therefore, the recordings from 1936 provide a representative image of the *juuz* before its mixing with the tonalities and the aesthetics of commercial music.

Example 1. Location of Muotatal valley on a map of Switzerland.

4. Wolfgang Sichardt (1911–2002) studied art history and musicology and wrote his dissertation entitled *Der alpenländische Jodler und der Ursprung des Jodelns* (*The Alpine Yodel and the Origin of Yodeling*) at the University of Jena. After the end of World War II, Sichardt was taken prisoner of war by the French and returned to Germany after two years. He obtained a position as a music librarian in Wiesbaden in 1953, where he worked until his retirement. Sichardt's publications are limited to the aforementioned monograph as well as a series of short articles in the years 1936–1939 and 1949, which he wrote in part as co-author of his supervisor Werner Danckert (1900–1970).

As part of his dissertation, Sichardt carried out six weeks of fieldwork in Switzerland during September and October 1936. He recorded yodels, folk songs, alphorn melodies, and cattle calls in various rural communities dispersed across Switzerland. Among these sound recordings are interesting examples of the Alpine yodel, which are fundamentally different from the style cultivated at that time in radio and record productions. The recordings that emerged from the field research in 1936 are in many ways important for the history of yodeling and the relationship between sound recordings and transcriptions in their historical reception.

Sichardt's field research also broke with guidelines for song collections, as written by the musicologist Walter Wiora (1938, 53) at the same time. Sichardt did not intend to adapt to musical-aesthetic conventions or select songs considered valuable. In contrast, his search for phenomena that resist the existing conventions was in the foreground, motivated by the challenge to prove the existence of "older layers" (Sichardt 1936a, 178) of music which were supposedly conserved for centuries and to document them on magnetic tape reels. Consequently, in his transcriptions, Sichardt did not attempt to dissolve or harmonize deviations from tonal and metric norms, but rather emphasized them all the more (Wey 2019, 159). In order to find the origin of yodel, Sichardt tried searching for unconventional singing styles. The more the tuning, the timbre and the meter of the yodels deviated from modern norms, the older they had to be, according to this reasoning.

Sichardt's reasoning took place under the methodological paradigm of "Kulturkreislehre," at that time popular in German anthropology. The methodology of Kulturkreislehre has been widely discredited since then, and the conclusions Sichardt published in his dissertation in 1939 are overall no longer considered valid. The transfer of stratigraphic methods from archaeology and geology was critically reflected in English-language publications, exemplified by the American anthropologist Clyde Kluckhohn in his 1936 essay, "Some Reflections on the Method and Theory of the Kulturkreislehre." He explains: "The Schichten concept is clearly geological, and the idea of 'cultural fossils' is clearly an analogy from palaeontology" (Kluckhohn 1936, 166). The questionable nature of this analogy was thus already uncovered at the time of the audio recordings discussed here.

However, the associated recordings provide a precious source as they document yodeling in different rural parts of Switzerland at a time when field recordings are very scarce. In addition, the reason why yodeling in Muotatal is considered an independent style is probably rooted in Sichardt's (1936a, 1939) publications. The recordings remained publicly inaccessible until 2008 when they were donated to the Vienna Phonographic Archive.

Sichardt captured a total of nine solo yodel songs in the Muotatal valley, of which the transcription in Example 2 represents one. Sizes of neighboring intervals are given below the melody and already indicate the non-equal-tempered structure of this particular melody.

Example 2. Transcription of a melody recorded by Sichardt (1936b) with interval measurements in cents given below the syllables.[5]

Regardless of the methodological and ideological issues in his publications, Sichardt proposed the existence of a local tonal system which he thought was a representation of archaic music from a pre-Christian era. He followed with the statement: “It is not enough to point out the instrumental example of the alphorn scale. The peculiar structural proportions are features of an independent vocal style” (Sichardt 1939, 37; translated by the author). Thereby, he dismissed the narrative of the harmonic series as the predecessor of equal temperament.

The existence of “peculiar” tonalities characterized by consistently sharpened or flattened degrees is emphasized in Sichardt’s transcriptions, particularly in the Muotatal recordings. The inclusion of these transcriptions in later scientific articles (e.g., Wiora 1958, 77) contributed to the fact that specific historical sound systems were attributed to yodeling in Muotatal. Such systems with their characteristic deviations from systems with equal temperament were not yet systematically documented, even though the technology necessary to carry out such measurements would have been available.

The further the tonality deviates from equal-tempered diatonic scales, the older and longer conserved Sichardt considers the melodies: The use of ekmelic tonal degrees was conceived to be a relic of a bygone era. The existence of a hitherto unknown sound system in Muotatal is clarified in the transcription in Example 3, where he indicates a sharpened fourth

5. Yodeling syllables are written in German and coincide with IPA symbols in this example; the vowels ‘o’ and ‘u’ are hence pronounced like the IPA symbols [o] and [u].

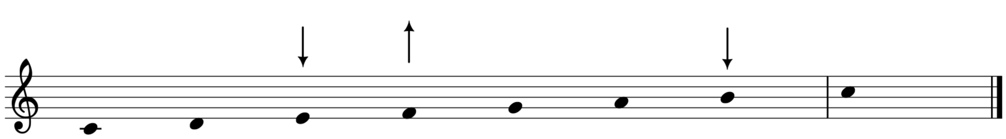
Example 3. Transcription with altered degrees suggested by Sichardt (1936a, 179).

degree and a flattened seventh degree of the scale. Inverted fermatas designate the shortening of specific notes.[6]

In 1979, ethnomusicologist Hugo Zemp conducted fieldwork in Muotatal, the results of which he presented in a series of four short movies (Zemp 1987). In one of these, titled *Head Voice, Chest Voice*, the subject of tonality is discussed and the construction of a tonal scale, pictured in Example 4, is introduced. His key conclusions, on which he elaborated again in an article published in 2015, can be summarized as follows: (1) a heptatonic scale provides the tonal framework; (2) there is the intonation of neutral thirds, denoted by an arrow down; (3) the fourth degree is sharpened,[7] as denoted by an arrow up; (4) the seventh degree is flattened, as denoted by an arrow down.

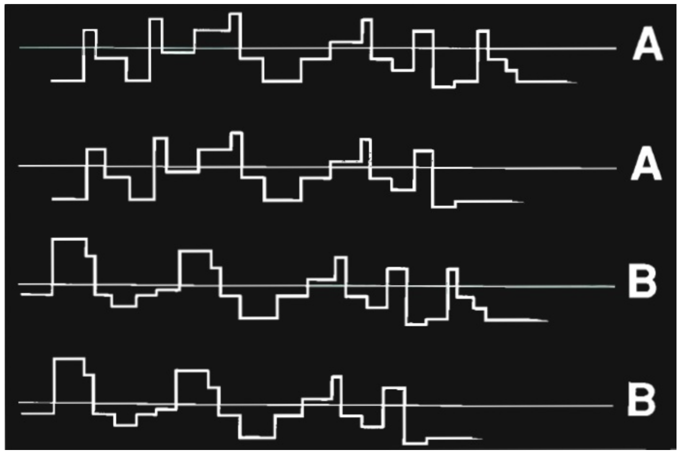
This observation raises questions for the transcription. Conventional staff notation is deemed unfit for representing non-equal-tempered tonal systems because it cages the tonality on and between five fixed lines. Zemp (1990) published alternative transcriptions like the line graph in Example 5 in an article on the making of his films. The horizontal lines in Example 5 denote the change between chest voice (below the line) and head voice (above the line). The letters on the right side denote the formal structure of a song, consisting of two phrases (A and B), each of which is repeated with slight variations.

During my own engagement with yodel from Muotatal, as well as with the *büchel*, a folded, trumpet-shaped variant of the alphorn, I was able to obtain a broad picture of the



Example 4. Transcription of the tonal scale of Muotatal yodels proposed by Zemp in his short film *Head Voice, Chest Voice* (1987).

6. The inverted fermata was introduced for the purpose of descriptive transcriptions by Abraham and Hornbostel (1909, 11) and defined as a "shortening of a single note." The amount of shortening remains unspecified.
7. In the Alpine region, the sharpened fourth is dubbed "Alphorn-fa," because it constitutes a characteristic element of alphorn music. This is hence again a reference to the harmonic series as an influence on tonality.



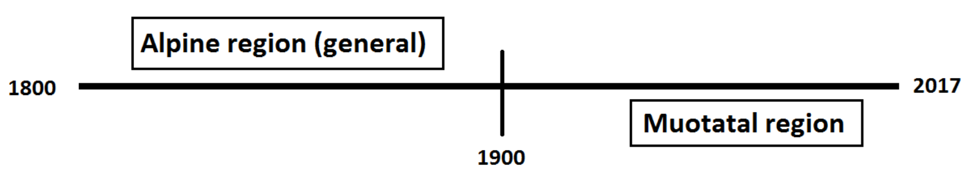
Example 5. Transcription of yodel melodies with denotations of the changes between head voice and chest voice by Zemp (1990, 72).

current musical practices in the valley since 2015. This study includes recent recordings of monophonic pieces, some of which are also present as different versions in earlier recordings. As the tradition of *juuz* continues to change, melodies are created and forgotten. The sample, deliberately adjusted to the size of those available from historical recordings, can only provide a snapshot of the current practices, and different angles using different recent recordings could be equally valuable.

Notes on the Localization of This Study, Data Retrieval, and the Analytical Procedure

Following the narrative laid out before, the analysis of recordings from 1936, 1979, and 2017 departs from the premise that in the case of Muotatal, some of the transformations happening in traditional tonal systems were delayed by at least a century and might hence be observable based on audio recordings. An illustration of the proposed shift in tonality along the timeline is given in Example 6.

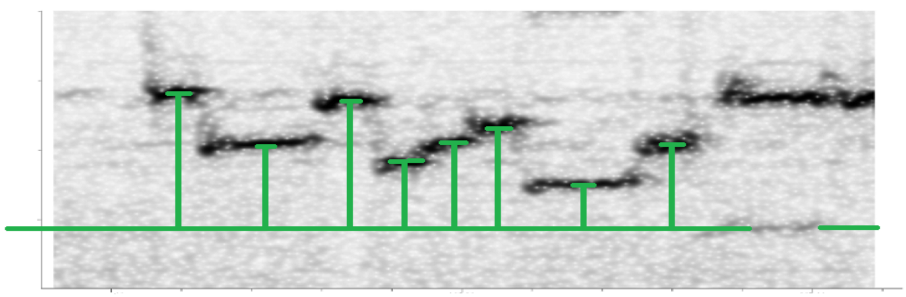
There are numerous studies on the subject of tonality, differing in aims and approaches. Studies could be placed very roughly into three groups: one group concerned with the perception of tonality, typically empirical studies carried out in the field of music psychology;



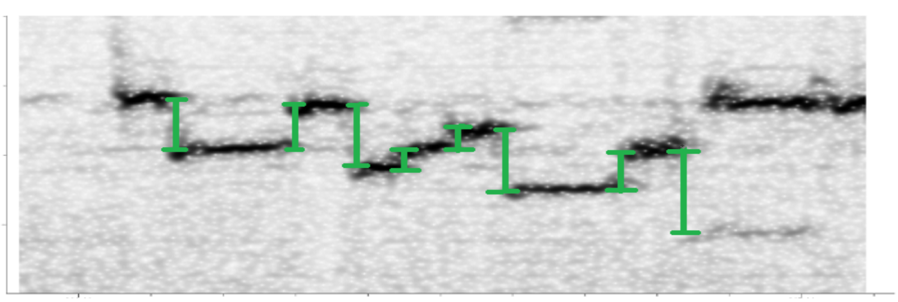
Example 6. Presumed timeline of shifts in tonalities towards 12-tone equal temperament.

a second group consisting of studies of automatic music information retrieval, carried out in the data sciences; and a third group of ethnomusicological studies concerned with descriptive analysis of culture-specific tonal systems, with this present study falling into the last category. The term tonality, along with its related terms, like "tonal system," "pitch structure," "tonal awareness," or "tonal feeling" (Vos 2000, 405), is in itself not easy to grasp. In his lecture from 2009, Kofi Agawu defined tonality as "a hierarchically organized system of relations animated by desire." He therefore notes that these relations of pitches are not just value-neutral outcomes, but are based on an aesthetic ideal.

To describe the tonal system, procedural decisions have to be taken cautiously. The decision of whether to measure horizontal or vertical relations between pitches poses a significant question. This problem is illustrated in two sound images. The first one (Example 7) depicts the vertical relations. To induce a specific tonal scale, the pitch of every note in the melody is measured in relation to a tonic, which has to be defined beforehand for the purpose of measuring its distance from other pitch classes.[8] In the second spectrogram (Example 8), horizontal relations are detailed. The tonal system is thereby induced by measuring neighboring intervals and determining the structure of those intervals.



Example 7. Illustration of vertical tonal relations.



Example 8. Illustration of horizontal tonal relations.

8. A pitch class is defined as a group of pitched sounds which "have some relation . . . of compositional or analytical interest" (Roeder 2001). For example, two notes belong to the same pitch class if they are separated by one octave.

As the data allow one to proceed either way, insights from interviews conducted with active yodelers have to be relied upon in order to determine which relations are meaningful in regard to these particular melodies. Two interview partners (representing different generations, born in 1941 and 1977, respectively) addressed this question and gave a clear understanding that the way this style of yodeling works is horizontal: When the same melodies as analyzed presently are sung in groups of three or more singers, the lead singer who performs the melody never adjusts his or her tuning to the bass, and instead focuses on the course of the melody, according to the interviewees. There is no stable tonic, and raising or lowering the final notes of the phrase during a performance constitutes a typical feature.

As indicated in Table 1, the three samples each comprise 600 to 700 intervals, with 696 intervals in the first recordings from 1936, 663 in the second (1979), and 678 in the third sample (2017). The fact that the first two samples are in the same range of size is a coincidence; in the third, it was deliberately chosen to include a similar number of intervals.

Determining the pitch in yodel is complicated by the fact that the fundamental frequency is oftentimes of marginal intensity in the overtone spectrum.[9] This implies that a determination of pitch through autocorrelation (and related algorithms) can produce misleading results. For example, the data will provide a downward second when the singer actually performs an upward seventh, or an upward fifth when one can hear a downward fourth. This problem is amplified by the fact that yodel melodies often span a wide ambitus, wherefore an octave cannot be properly assigned based on the measurement of just one partial. A discussion of retrieving valid pitch measurements becomes necessary. Zemp (2015) took the following approach:

> The figures in *cents* are approximate. *Sonic Visualiser,* the software that I use, presents real time spectrograms, where the horizontal line of the fundamental tone (harmonic 1) in chest voice is difficult to measure. . . . I usually check the fundamental frequency and the second harmonic at the octave at the same time, varying the cursor until it reaches the middle of harmonic 2. With a very slight movement of the cursor, the value of the frequency can vary more than 10 cents. Despite this variability, the measurements do

Sample Number	**Recording Collector**	**Year Collected**	**Number of Pieces**	**Number of Intervals**
Sample 1	Sichardt	1936	9 pieces of solo yodel	696 intervals measured
Sample 2	Zemp	1979	8 pieces of solo yodel	634 intervals measured
Sample 3	Wey	2017	10 pieces of solo yodel	679 intervals measured

Table 1. Summary of the data used for the present study.

9. This phenomenon was already pointed out as early as 1965 by Graf (1965, 20).

> allow us to see if an interval is close to a major third, a minor third, or systematically near to a neutral third. (Zemp 2015, 65)

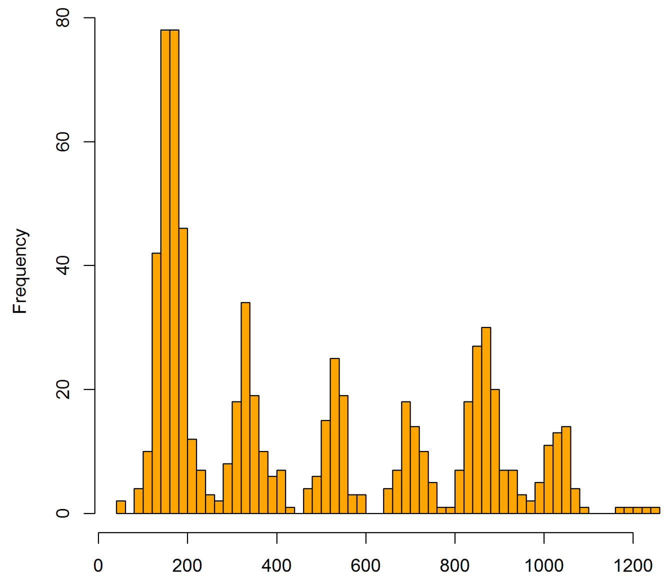
On the downside, 10 cents constitute a considerable margin of error; on the upside, the measurement is approaching the pitch perceived aurally, instead of the frequency with the highest intensity. The resolution for retrieving pitch has to produce meaningful results regardless of noise, reverberation, and the different peak intensities in the overtone spectrum. Therefore, clearly measurable, stable segments of each stable note were selected and a spectrum obtained. A set of harmonics, including overtones in the range of 2000 to 3000 Hz, were measured. This approach is unusual, yet not completely novel. It was already described by Ambrazevičius in a study on the tonality of homophonic Lithuanian songs: “It is comfortable to start with the narrow-band spectrogram to identify such segments: the spectrogram shows distinctly the undulating lines of harmonics. Then [the] spectrum of the selected segment is obtained and sets of harmonics of the individual voices are identified in the spectrum. Certain outstanding harmonics are chosen and their frequencies are measured. Logarithmic relationship of frequency and pitch is applied and the pitches are calculated” (Ambrazevičius 2014, 54).

These concerns led to the decision to adopt Ambrazevičius’s method and thereby measure multiple overtones within a range between 2000 Hz and 3000 Hz. This procedure represents the aural impression while lowering the margin of error below five cents. Reaching the threshold of five cents is critical, as it is widely regarded as a limen for frequency discrimination by the ear of the listener. Changes below this threshold are not audible and henceforth not relevant to the perception of the melody. Lucerne Audio Recordings Analyzer (LARA) was used for pitch measurements.[10] LARA allows placing a grid over a given overtone spectrum in order to determine the fundamental frequency with respect to multiple overtones.

RESULTS

A histogram of all the neighboring intervals is obtained for the data of each sample. Example 9 depicts the distribution of interval sizes in the recordings from 1936. The data are split up into bins of 20 cents in all of the following histograms. Two features in Example 9 are worth noticing at first sight. First, there are visibly distinct classes of intervals in place, a concise tonal system, with gaps in between indicating interval sizes omitted in the performance. The second observation worth noting is the presence of one single peak in the range of seconds (50–250 cents) and one peak in the range of thirds (250–450 cents). This means that there are no minor and major seconds, or minor and major thirds, but just one interval in each of those ranges.

10. Retrieved from https://www.hslu.ch/de-ch/musik/forschung/performance/lara/, January 12, 2019.



Example 9. Distribution of pitch in Sample 1 (Sichardt 1936b).

Confronted with an unknown tonality and visibly discrete pitch classes, a detailed description of the pitch classes can highlight possible explanations. Table 2 contains descriptive statistics on the pitch classes: seconds (50–250 cents), thirds (251–450 c), fourths (451–650 c), fifths (651–750 c), sixths (751–950 c), and sevenths (951–1150 c). The last column indicates the distance between the median values of succeeding interval classes. Those range from 152 cents (three quarters of a whole tone) to 199 cents (perceived as a whole tone). The small range of less than a quarter tone may be interpreted as an approximation to equiheptatonic tuning.[11]

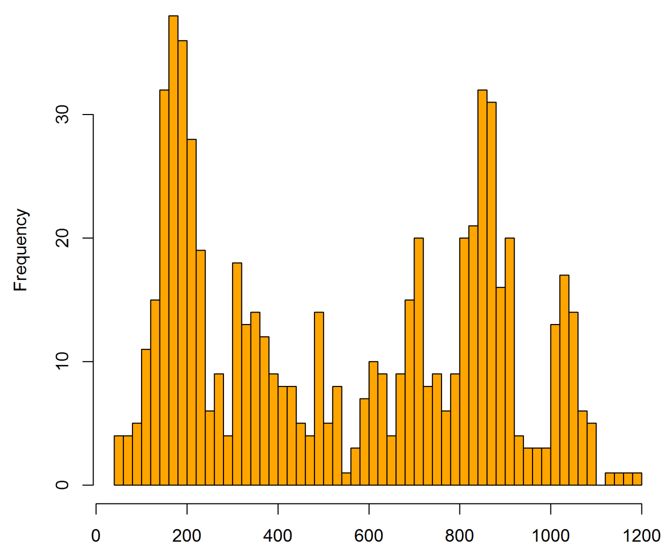
Interval	*n*	Min	1st Qu.	Median	Mean	3rd Qu.	Max	Distance to the preceding median values
Seconds	281	59	144	162	161.8	180	249	162
Thirds	104	264	319	337.5	340.6	358	426	175.5
Fourths	77	462	517	536	531.6	547	648	198.5
Fifths	56	652	691	700.5	703.4	720	748	164.5
Sixths	121	756	841	862	864.4	886	948	150
Sevenths	52	954	1009	1030	1028	1048	1083	168

Table 2. Description of interval classes in Sample 1 (Sichardt 1936b). All intervals are given in cents. Five intervals are outside the documented range (i.e., between 0 and 50 or between 1151 and 1249 cents).

11. The idea of equiheptatonic tuning is new to the analysis of alpine vocal music, but it has been discussed in a number of musics in other world regions (cf., e.g., Jones 1980; Rahn 2019).

The second sample looks more variable (Example 10 and Table 3). Clear peaks are evident, but no discrete pitch classes emerge. A variety of reasons, like a generally less stable intonation, variance among separate melodies, and the use of vibrato could contribute to the picture showing overlaps of interval classes. Since the data consists of neighboring intervals, pitch drift does not affect the overall results. Pitch perception, both absolute and relative, is categorical, which means that the continuous variable of frequency is perceived to be divided into discrete categories (Aruffo, Goldstone, and Earn 2014, 187). These categories may even overlap: depending on the melodic context, the same frequency interval may be perceived in different categories. Therefore, a non-discrete distribution of intervals may still represent a single underlying tonality.

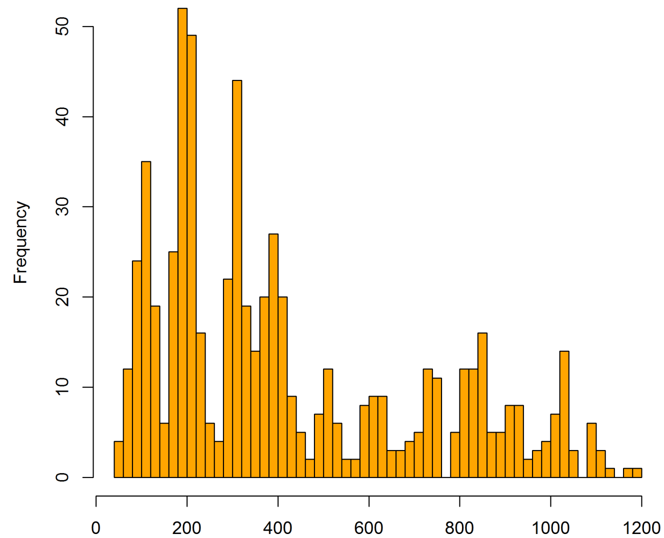
The third sample (Example 11) provides a visibly different account of tonality compared to the two shown above. The number of peaks is increased, which means that there are more different sizes of intervals that are used in singing and are therefore deemed desirable in this particular tonal aesthetic.



Example 10. Distribution of pitch in Sample 2 (Zemp 1979).

Interval	*n*	Min	1st Qu.	Median	Mean	3rd Qu.	Max	Distance to the preceding median values
Seconds	191	54	146.5	173	169	199.5	245	173
Thirds	91	250	309.5	339	343.1	375.5	448	202
Fourths	65	453	494	538	549	608	649	199
Fifths	58	650	691	702	703.6	717.8	749	164
Sixths	157	755	824	857	852.8	881	945	155
Sevenths	62	959	1016	1032	1036	1056	1149	175

Table 3. Description of interval classes in Sample 2 (Zemp 1979). All intervals are given in cents. Ten intervals are outside the documented range (i.e., between 0 and 50 or between 1151 and 1249 cents).



Example 11. Distribution of pitch in Sample 3 (Wey 2017).

In order to tabulate the results, the classes of seconds, thirds, and fourths have to be split up, because Example 11 clearly shows two peaks in each of the respective ranges. Seconds are divided into minor (50–149 c) and major seconds (150–249 c), thirds into minor (250–349 c) and major (350–449 c) thirds, and fourths into perfect fourths (450–549 c) and augmented fourths (550–649 c). Complementarily, the respective division is applied to the classes of sixths and sevenths. In Table 3, the classification of Table 2 was kept, as the histogram in Example 10 provides no clear indication of a different set of peaks.

Interval	***n***	**Min**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max**	**Distance to the preceding median values**
Minor Seconds	96	52	93.75	103.5	102.8	116.5	146	103.5
Major Seconds	149	152	184	198	197.8	214	249	94.5
Minor Thirds	97	253	298	309	309.3	318	349	111
Major Thirds	87	351	373	392	391.3	405.5	444	83
Perfect Fourths	31	450	489.5	510	503.9	520	546	118
Augmented Fourths	32	554	591.5	611	608.2	627	649	101
Fifths	31	664	703.5	728	719.5	738.5	749	117
Minor Sixths	38	750	800	816.5	811.8	830.8	848	88.5
Major Sixths	38	850	856	891	890.7	914	943	74.5
Minor Sevenths	31	953	1000	1012	1014	1034	1043	121
Major Sevenths	11	1050	1087	1098	1095	1104	1135	86

Table 4. Description of interval classes in Sample 3 (Wey 2017). All intervals are given in cents. Thirty-eight intervals are outside the documented range (i.e., between 0 and 50 or between 1151 and 1249 cents).

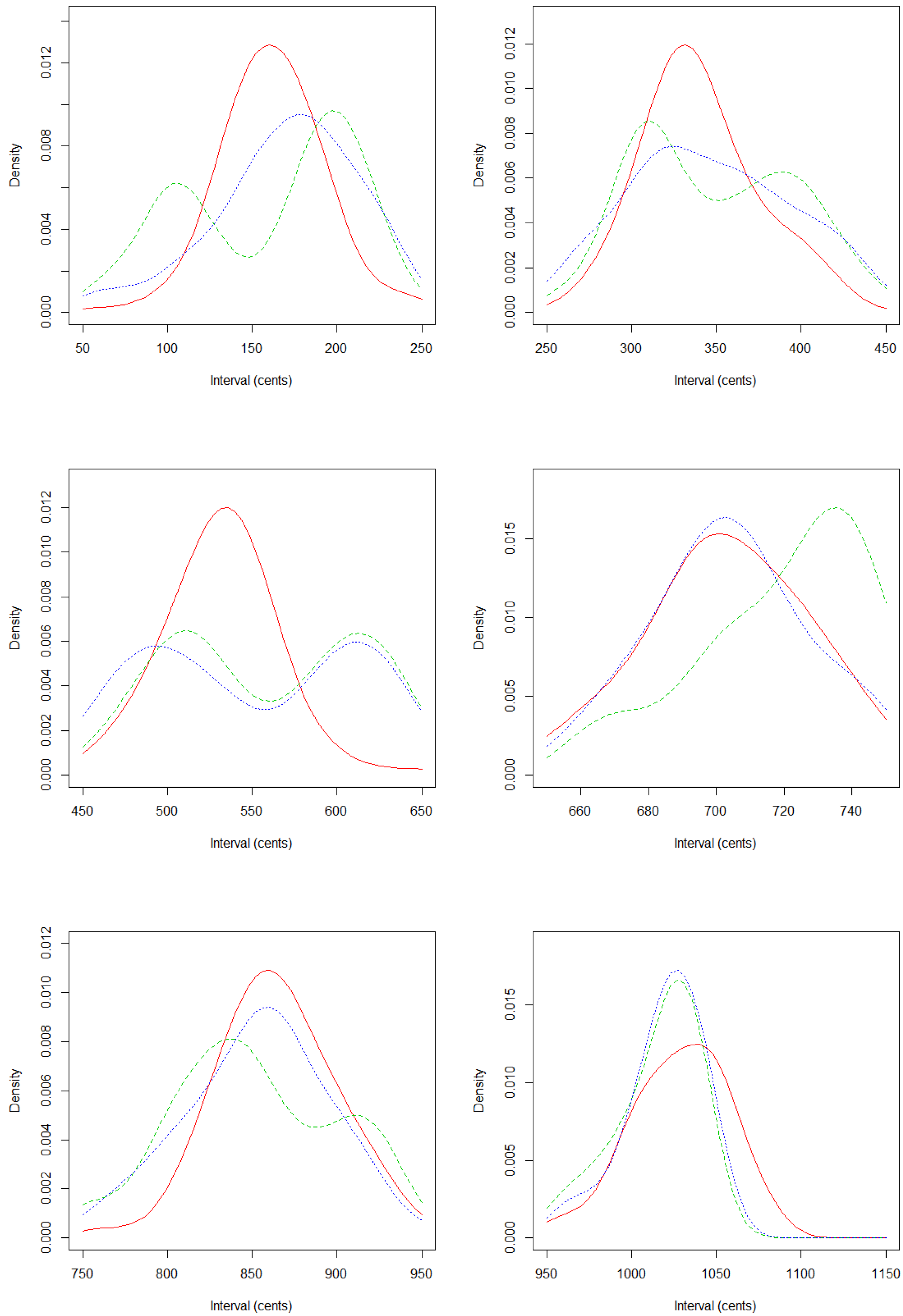
In order to observe changes in tonality, each class of intervals found in Sample 1 (seconds: 50–250 cents; thirds: 250–450 cents; fourths: 450–650 cents; fifths: 650–750 cents; sixths: 750–950 cents; sevenths: 950–1150 cents) is compared separately across time applying comparative density of the three samples (Example 12).[12]

In the category of seconds (50–250 cents), an evident change is visible, from neutral seconds in Samples 1 and 2 to minor and major seconds in Sample 3. The comparison of thirds (250–450 cents) results in a similar picture: while thirds used to tend towards neutral intonation (350 cents), they split into categories of minor (300 cents) and major (400 cents) thirds in Sample 3 (2017, green). It remains important to note that the neutral third is not consistently absent—in particular contemporary examples, it has been measured nonetheless. In the category of fourths (450–650 cents), one single peak can be observed in the 1936 recordings but two peaks in the data based on the newer recordings. The interval omitted in Sample 1 is the tritone, an omission that can be interpreted as another shift towards a diatonic tuning based on whole tones and semitones. Concerning fifths (650–750 cents), the data demonstrate a continuous shift toward larger intervals, evident in 2017. No explanation for this phenomenon can be derived from the theoretical groundwork laid out before, yet this change seems too decisive to be neglected. Similar results are shown for the range of sixths (750–950 cents), where the samples from 1936 and 1979 are almost congruent, but the sample from 2017 diverges. The comparison of sixths shows almost congruent distributions with neutral sixths (850 cents) in Samples 1 and 2, and two peaks in Sample 3. In the case of sevenths (950–1150 cents), a divergence can be observed between the first and the second sample.

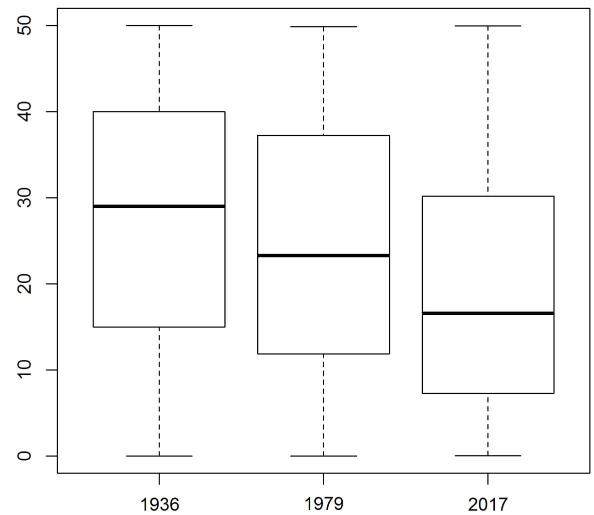
In order to obtain a more comprehensive look at the shift toward equal temperament, the deviations from the equal-tempered scale can be compared across time. By calculating the difference of each interval to its closest semitone, distributions of deviations can be compared across the three samples. Example 13 demonstrates the result. The deviation can range from 0 to 50 cents, as 50 cents constitute the maximum distance to the closest (equal-tempered) semitone. The thick black line in Example 13 indicates the median values. Half of all values are within the rectangular boxes (one quarter in each part of the box below and above the thick black line), and the whiskers mark the minimum and maximum values.

As demonstrated in Example 13, the median deviation is 29 cents in case of the 1936 sample, dropping to 23 cents in the 1979 sample and further down to 17 cents in 2017. This observation is generally in line with the narrative laid out before, as well as with the previous research cited (Ringli 2006, Zemp 2015, Wey 2019).

12. Density plots were created using the *sm.density.compare* function from the *sm* package (retrieved from https://cran.r-project.org/web/packages/sm/index.html, December 4, 2017) in R (R Core Team 2020). The interval classes are divided at midpoints of the 20-cent increments in the histograms above.



Example 12. Comparison of intervals in Sample 1 (1936, red), Sample 2 (1979, blue) and Sample 3 (2017, green).



Example 13. Deviation (0–50 cents on the vertical axis) from equal-tempered tuning in samples from 1936, 1979, and 2017.

Conclusions

Some of the changes described above can be explained through existing theories and narratives while others cannot, and thus may be accidental. The tonality of the Muotatal *juuz* was already described by Sichardt (1939) and Zemp (1987, 2015), both of whom presented a tonal scale with vertical tone relations to a fixed fundamental tone. Zemp suggested that the ekmelic intervals, especially the neutral third and the sharpened fourth, were disappearing due to a recent shift toward equal-tempered intonation (Zemp 2015, 63). This thesis can be supported by the material presented in the current study. Neutral intervals could still be heard in 2017, but they were not performed in a systematic way as observed in the 1936 sample. Meanwhile, the tonal system observed in the recordings from 1936 is demonstrably different from the equal-tempered system, with a tonality shaped by neutral seconds, thirds, sixths, and sevenths, which on average deviated more from the 12-tone equal-tempered scale than was the case in later practice (see Example 13). Although based on a heptatonic framework, major or minor chords played no significant part in 1936.

A tonal shift toward equal temperament constitutes the main conclusion of the present study. The analysis of interval structures suggests that tonality shifted away from a local system based on neutral intervals toward equal-tempered intonation and the intervals of major and minor scales as we know them today. A decline in deviations from the equal-tempered norm happened between each sample period. Focusing on specific intervals, shifts occurred throughout both the observed periods (1936–1979, 1979–2017), with no observable difference in some cases between two samples.

The ubiquitous presence of equal temperament has spread to yodeling in Muotatal, although with a delay of several decades. Equal temperament has for some time been considered the only "right" way of singing; however, this idea has eroded in recent years (Ammann, Kammermann, and Wey 2019, 205). As we experience interest and demand for different ways of listening to and performing tonal systems, should we aim at improving notation for different tonal systems, especially for those based on horizontal tonal relations? In the past, such attempts have always largely failed, due to the fact that conventional staff notation provides the most efficient available notation technology (Cohen and Katz 1979, 101) and is the only system understood by a wider public. In addition, issues were raised on the questions of how to approach the description of tonality, pitch drift, and vibrato, some of have yet to be addressed in the case of Alpine yodeling.

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