Singing in Class: Analysis of Children Learning a New Song

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Abstract: Teaching and learning new songs in class is an integral cultural practice. This paper focuses on a singing lesson and studies the complex relations among the target song, children's song acquisition and the teacher's instructions. However, instead of simply examining pitch accuracy or ratings, this paper proposes a novel methodology for analysing song learning in class. First, a transcription method is used to document a video-recorded lesson. Second, syllables are identified as both the essential components of the grammar of songs for children and the fundamental units for analysing singing in terms of pitch, timing and articulation. The individual singing of three children, divided into the syllables of the target song, is examined for these three properties. Third, a comparison between the song model and the children's singing reveals how rule-breaking in the song corresponds to the children's difficulties in singing. This detailed and subject-related analysis exemplifies the complex dynamic among the teacher, the object and the learner and is a contribution to the research of subject-related didactics.

Keywords: *Didactics, grammar of songs for children, singing, singing analysis, song learning.*

Introduction

Singing is an important part of daily life in educational institutions (e.g., kindergartens and elementary schools). Generalist teachers teach children new songs or repeat songs that they already know as part of their daily routine. Furthermore, in the context of group singing, the rules and conventions of a cultural practice, such as following rules for well-formed joint singing, are consolidated. While singing together, all participants simultaneously contribute to something whole. They organise socially to produce temporal, tonal and lyrical features that blend to form a coherent song.

The focus of this research paper is on the song singing process of three children and how they individually participated in the joint acquisition of a new song in class. I have devised a new method for studying children's individual singing in the context of class singing at various levels. This method involves a series of analytical steps utilising different software, such as Melodyne and Audacity, to ascertain information about the pitch, timing and articulation of syllables. The resulting analysis of singing processes is presented in a visually simplified manner that preserves the complexity by focusing on the syllables and their pitch, timing and articulation. Furthermore, the reconstruction of the teaching–learning of a song during a lesson accounts for the target song with its grammatical rules. Finally, by contextualising individual singing processes within the framework of the course of the lesson, it is possible to increase understanding of how songs are taught and learned in class.

Literature Review

Formal Song Transmission

Research on singing has gained much attention in recent years (e.g., Russo et al., 2020), and even in the young discipline of didactics (Schneuwly, 2021), teaching and learning songs is gaining attention as an upcoming topic (e.g., Savona, 2022). Teaching a song requires a broad range of competences, including a wealth of knowledge, skills and strategies (Stadler Elmer, 2021, 2022). Aside from teachers and their strategies for song leading, the children, following this leading, are the counterparts of the song practice at school. Children sing the song that the teacher provides, imitate it, practise it and incorporate it as a kind of cultural product and symbol. The song, therefore, is the object of teaching and learning. It is the teacher's task to select a song and repertoire that are feasible and appropriate for the children, both in terms of melody and lyrics. During teaching, the teacher may segment the song and work with the parts and the whole in many

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different ways to facilitate the transmission. The three aforementioned components — teacher, children and song (object) — comprise the didactic system (Chevallard, 1991; Reusser, 2018; Schneuwly, 2021). Didactics, as a scientific discipline, studies the dynamics of these components with the goal of improving understanding on how the actors interact, how the objects are selected and prepared to become teachable for the teachers and learnable for the pupils and how teaching evolves constantly (e.g., Stadler Elmer & Hoyningen-Huene, 2022). The interactions between the participants constitute the practice and can be observed during a lesson.

Song Leading

Generally, the literature on formal singing in the classroom is scant, but it has been growing in recent times. For example, articles with the following themes have been published on formal singing: problems with training pre-service teachers (Fündeling, 2022; Hennessy, 2017), the question of whether music lessons are taught by generalist trained teachers or by specialists (Aróstegui & Kyakuwa, 2021) and a methodology to transcribe systematically the actions during song transmission (Savona et al., 2021). Liao and Campbell (2014, 2016) tackled the topic of song leading in a pioneering manner. In a comparative study in the United States and Taiwan, they investigated teachers' song leading in different schools in both countries and identified different components of the teachers' song-leading actions. Knigge et al. (2021), in one of the few studies that have addressed singing in kindergarten, examined singing in schools by using an online questionnaire. Among other things, they also explored the question of how kindergarten teachers sing with children and what repertoire they use. Knigge's research, along with the studies conducted by Liao and Campbell, provides valuable insights into music lessons in kindergarten. However, these studies lack the perspective of the children and an overall overview of the activities throughout a lesson.

To really investigate and analyse music teaching — that is, to make explicit how teachers organise teaching a new song in class — Stefanie Stadler Elmer and her team (including the author of this article) developed a new tool and transcription system known as the Lesson Activities Map (LAMap; Savona et al., 2021). For the development of this transcription system for singing lessons, we identified the relevant activities that generalist teachers perform, and we generated symbols and icons to represent these activities. Hence, the systematic transcription of the constitutive activities visualises the activities and provides an overview of the lesson with respect to what teachers do while teaching a song in class. This newly designed transcription system, LAMap, makes it possible to contextualise targeted phenomena. Figure 1 shows an example of a LAMap. The figure 1 is divided horizontally into two sections. The upper area describes the teacher's actions, and the lower area describes those of the children; the speaking line in the middle separates the two areas. This line represents the speech actions, both from the teacher's side and from that of the children. The grey rectangles represent the song being sung. These rectangles depict whether the song is taught in its entirety or in verses and whether both the lyrics and the melody, or just one of these components, are incorporated into the lesson (see Figure 2). This descriptive overview of a lesson is based on video recordings and repeated systematic observations. The LAMap reveals temporal and transient aspects and their organisation and gives a comprehensive overview of the lesson.
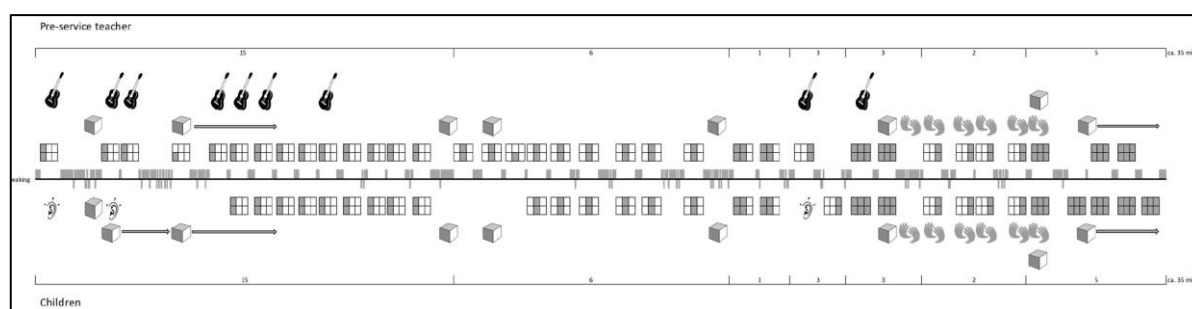

Figure 1. Example of a Lesson Activities Map Showing the Recurrent Activities of a Lesson on its Temporal Occurrence (Savona et al., 2021)

Song Leading Activities Key		
Symbols and Icons		**Definitions**
generalist teacher · children	speaking line	spoken communication between generalist teacher and children
	single verse	verse(s) of the target song momentarily not in focus
	single verse, melody and lyrics	singing with lyrics
	single verse, lyrics only	lyrics recited, i.e. verse metre is implicitly present
	single verse, melody only	singing the melody without lyrics by producing single syllables, e.g. la-la-la
	single verse, rhythm only	rhythm without lyrics or melody, expressed by body percussion or vocal sounds
	sounds with voice and body	sound production with the voice and/or the body without metre
	listening	instruction to listen attentively
	gestures or body percussion	gestures related to the lyrics' semantic content or metric sound production by body percussion
	movements	movements not related to the lyrics' semantic content (dancing, marching, etc.)
	material support	use of realia such as pictures, tissue paper, puppets etc.
	electronic devices	song reproduced or accompanied by digital support
	piano	use of instrument as song accompaniment or on its own
	guitar	use of instrument as song accompaniment or on its own
	percussion instruments	use of instrument as song accompaniment or on its own

Figure 2. Icons and Symbols Representing the Recurrent Activities During Formal Song Transmission (Savona et al., 2021)

The LAMap, as a systematic analysis of the song leading and singing process, reveals the relevant activities while teaching and learning a new song. However, in terms of an overview, the LAMap does not provide information about *how* the actions are carried out, and hence, not about children's individual singing. To provide a comprehensive description of the way individual children participate in class, as well as their individual singing, this article requires a new method that can capture the intricacies of their singing in greater detail.

The children's individual singing merges together to create a unified sound. In this context, it is crucial to analyse the individual voices within a lesson's framework, since children engage in interactions with both their peers and the teacher. Therefore, studying individual singing in isolation is inadequate, as it fails to capture the dynamic interplay between all participants. Besides analysing the children's individual voices, the method enables an analysis of the children's singing while they perform the transition from non-singing to singing. This has not yet been studied systematically, except for in previous publications by the author (A. E. Hürlimann, 2022; A. Hürlimann & Savona, 2022).

Singing Analysis Methodologies

Depending on the research question, the analysis of singing concerns a multitude of properties, such as pitch, vibrato, timing, articulation, tempo, vocalisation, expression and phrasing. For instance, an analysis of solo singing differs from that of singing as a group. The vocal alignment to pitch and synchronous timing are unique in joint singing and thus differ from solo singing. Therefore, the analysis of individual singing in the context of group singing needs to be done differently compared to the usual methods of analysing solo singing. Furthermore, recording the singing voices as solo or collective should be considered, as should the software available for the acoustic analysis and visualisation. According to Hutchins and Peretz (2012), pitch accuracy is a crucial factor when it comes to what constitutes judging singing ability. Other researchers (Larrouy-Maestri & Morsomme, 2014; Watts et al., 2003) have confirmed that intonation is an important criterion for defining voice quality, along with tone quality and musicality. As Larrouy-Maestri and Morsomme stated, the definition of accuracy varies depending on the author, but its measurement is always based on various ways to calculate the fundamental frequency.

> "In a melodic context, acoustical analysis consists first in the segmentation of the auditory signal and the fundamental frequency (F0) estimation. [...] Then, the F0 of each note produced can be compared with the target but also between the notes of the performance itself." (Larrouy-Maestri & Morsomme, 2014, p. 11)

Devaney (2020) also stated that a fully automated analysis of monophonic recordings requires the following three steps: segmenting the digital audio file into individual notes, estimating fundamental frequency (f0) and providing note-wise summaries of f0 traces. Important developmental steps in the automatic analysis of singing have led to software being able to automatically segment the audio signal into individual notes; this includes the commercial Melodyne by Celemony and open-source Tony software (Mauch et al., 2015). After the notes have been segmented, different models and algorithms are used to calculate and summarise the information. The acoustical analysis of singing using different software has been widely studied in several studies of singing, such as those of Pfordresher and Demorest (2020), Dalla Bella et al. (2007) and Cuesta et al. (2018). What follows is a concise summary of these research findings. Pfordresher and Demorest (2020) analysed singing accuracy with the help of an automated online measurement. In the process, the test persons were guided through various tasks, such as one in which they recited well-known songs by heart or sang a melody in the sense of call-and-response. An algorithm calculated the average of the individual notes sung and compared it with the given template. This test offered automated analysis for a defined set of brief melodies. Dalla Bella et al. (2007) asked occasional singers to sing a well-known song. They analysed the sung performance with an acoustic-based method and compared the results with those of professional singers, concluding that only a minority of the occasional singers made numerous pitch errors. This research used *praat*, which is free and open-source software used for the analysis, synthesis and manipulation of speech and other sounds. Cuesta et al. (2018) investigated several expressive characteristics of choir singing, with special emphasis on unison performance, to study how singers blend and interact with each other by analysing their f0 dispersion, intonation and vibrato. Devaney (2020) discussed the limits of various automated systems, stating that the 'automatic analysis of multi-part singing and singing with accompaniment is a difficult technical problem that has yet to be solved, and current approaches achieve only limited accuracy' (p. 137). Measuring by a machine rather than by ear may come at a cost of the time taken for note-by-note analysis. Some human checking and subjective judgments are still required (Pfordresher & Demorest, 2020). These difficulties also apply to the data of this research project. First, individual voices are studied in the context of a music lesson in class, in which the teacher sings along with the children and is thus audible as an additional voice in the audio recording. Second, various aids, such as instruments, body percussion or objects, are incorporated in the lesson, which also complicates the acoustic analysis of the recordings. And third, in the sample lesson of this article, the teacher accompanies herself on the guitar, which also makes software analysis more difficult. Studying the children's singing in class was challenging because the children were supposed to follow the lesson as normally as possible but the microphones were a distraction. A few of the children either sang exaggeratedly into the microphone or held it up to their mouths using just one hand, resulting in some instances whereby the microphone was either dropped to the ground or became detached from its fastening on their clothing. Consequently, certain recordings contained background noise and exhibited fluctuations in the volume of the captured voices. Due to these difficult circumstances, determining pitch could not be achieved using automated software; therefore, an additional manual analysis was required. The research team wanted to create a framework that would be as authentic and as non-invasive as possible, which necessitated this research design amid the difficult circumstances.

The aim of this research is not only to determine pitch but also other properties, such timing and syllable articulation with the objective to obtain a comprehensive understanding of how some children participate in class singing and how they follow the teacher's modelling of a new song. Learning a new song includes — as well as singing in tune — articulation of the syllables of the lyrics and producing correct timing in terms of phrasing and meter on the basis of a regular pulse. Analysing the learning process also means accounting for deviations from the rules, such as the production of glissandos, temporal irregularities, blurred articulations and the omission of elements. This research project places significant emphasis on children's singing, encompassing both a song and its structural elements as well as the manner in which individual syllables within the song are sung. Two research papers have done interesting work in this regard. The methodology developed by Stadler Elmer and Elmer (2000)—the Musical Micro Analysis Tools—is a suite of tools for analysing musical vocal production in the research field of singing. In comparison to *praat*, which was primary designed for speech analysis, this methodology is tailored to singing. The acoustic analysis includes two algorithms for the calculation of pitch, and by providing hertz or cents, it is adaptable to any tonal system. The methodology by Stadler Elmer and Elmer is not automated, since it requires actively listening to the syllables in order to achieve reliable analysis. For the notation of this information, Stadler Elmer and Elmer developed a system in which pitch and time are visualised on a continuous scale as well as glissandi, breathing, singalong and instructions. The combination of the analysis software and the notation system enables a reliable description of the sung structure, taking into account pitch, syllables and timing. The micro-analytical method for song analysis developed by Stadler Elmer and Elmer is very helpful for studying a song action, its structure and its processes of change as a result of learning and development, but it is very elaborate and time-consuming.

Zadig et al. (2016) analysed singing in a choir situation. They stated that methods for identifying and studying the actions of individual choir singers are very scarce. To fill this gap, Zadig et al. developed and evaluated a visual–auditory method using multi-track recordings to collect and analyse data from individual choir singers. They analysed the audio with

Melodyne and Steinberg Cubase 5 software. Their method sought to identify the actions and interactions between individual singers as well as among the entire choir, thus providing a comprehensive understanding of choral voice dynamics (Zadig et al., 2016). Choir singing is an informal activity that occurs on a voluntary, extracurricular basis. Choir rehearsals typically centre on learning polyphonic songs with the goal of an eventual performance. In contrast to choir singing, the singing observed in the present research project is unisono (monophonic), albeit produced simultaneously with many voices. This research focus is on the interaction between children singing the same melody and the teacher's guidance by the target song model, rather than the polyphonic interplay between the different voices in a choir. The absence of a suitable approach to analyse several voices singing together, as highlighted by Zadig et al., also concerns the investigation of singing in class. The methodology by Zadig et al. cannot be directly applied in the school context. Although their close-up analysis (e.g., Zadig et al., 2016, p. 10, Figure 5) provides valuable insights into pitch and potential ornaments or embellishments, it falls short of providing information about non-sung syllables and articulation.

Methodology

Data Collection

This research was carried out as part of a project that aims to reconstruct the interactions between teacher and children while singing a new song in class. For this purpose, the research group followed 10 students in a university's teacher education programme during their training over a period of three years. The students participated voluntarily. Each year, a single lesson with children at a kindergarten lower school was videotaped and subsequently discussed with the teacher during a video-based interview. The teacher watched her lesson and commented on her actions and thoughts.

In addition, a chosen group of volunteer children was equipped with microphones during the third lesson to facilitate the reconstruction of their singing. Furthermore, their singing was not analysed with respect to pitch accuracy alone but by using the syllables as the basic unit, including pitch, timing and articulation. In this specific lesson, only three out of seven children volunteered for the recording. Here, they are named Kira, Mia and Klara, and they are five years old. As a result, this study provides insights into how three children individually adapt their singing to the song model.

Exemplary Analysis of the Three Children's Singing in Class

To analyse the children's singing, the song model was segmented into its syllables, and each syllable was individually noted horizontally on the x-axis, as shown in Figure 3. A syllable is a phonological unit that combines consonants with a vowel or double vowel. Syllables are combined to form words, form the musico-linguistic units of a song and can therefore be analysed in this complex system of singing together (Stadler Elmer, 2015, p. 60, 2021, p. 6).

The first step of analysis consisted of segmenting the target song into phrases and their respective syllables. The teacher's singing of the target song and the produced syllables are visualised in Figure 3.
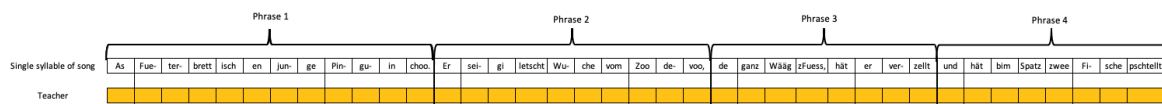

Figure 3. The Target Song, Segmented Into its Phrases and Syllables, as Sung by the Teacher.

This segmentation of the song text into its phrases and respective syllables was the first step of the analysis of the children's singing. The second step concerned an analysis of each individual child's singing at the basis of the microphone recording. It began by identifying the syllables reproduced, in whatever form, and allocating them to the ones of the song model. In Figure 4, the child's reproduced syllables are marked in yellow in the line below the song model. In this way, the produced syllables can be easily compared to the ones of the song model, and the omitted ones become apparent.
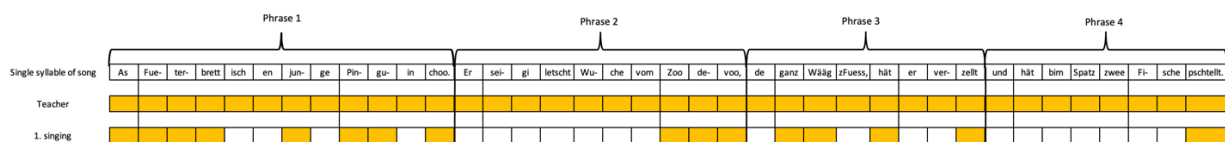
Figure 4. Kira's First Singing, Showing Sung Syllables (yellow) and Omitted Syllables (white), in Comparison to the Model Song Sung by the Teacher (top line).

In the third step, it was crucial to assess the quality of the syllables produced by the child. To achieve this, the syllable was deconstructed into its defining linguistic and musical properties. With reference to Stadler Elmer's (2021) grammar of songs for children, which conceptualises songs based on their tonal, temporal and linguistic rules, the relevant properties for this analysis were identified as pitch, timing and articulation. Timing was analysed to assess how far the child had been singing the syllable in synchrony with the teacher, and the focus was therefore on the syllable onset. Also,

the child's singing was compared with the teacher's sung melody; hence, the focus was on the pitch. Lastly, the child's articulation of the syllable was analysed in terms of vowels and consonants.

Figure 5 introduces an example of how this stepwise analysis is represented. The three criteria—the analysis of the syllable onset, pitch and articulation—are indicated on the left on the y-axis. Together, they specify the manner in which the child produced each of the syllables. If the sung syllable matches the model in the respective property, the box remains white. However, if the syllable is not sung faithfully to the model, the box is marked grey (see Figure 5).
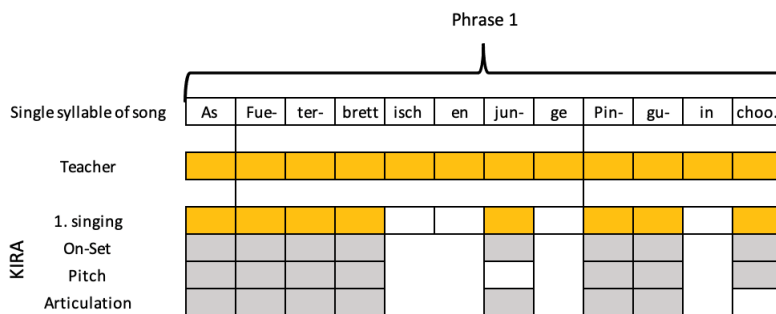

Figure 5. First Singing of Child Kira with the Respective Properties.

Figure 5 shows the segmentation of the song into its phrases and respective syllables. In the first phrase, Kira sings eight of twelve syllables, which are marked as yellow boxes. The four missing syllables are indicated as white boxes.

In the second step of the analysis (see above), the twelve syllables were examined for their corresponding properties concerning onset, pitch and articulation. These properties are represented as three separate lines (see left on y-axis) below the line with the child's sung syllables. If the particular property of the child's sung syllable matches the teacher's singing, the box remains white. If the property deviates somehow from the model, the corresponding box is marked grey. In Figure 5, we see that the quality of the eight sung syllables differs from the teacher's model. Kira, in her first reproduction in class, neglected almost entirely the musico-linguistic qualities of her produced syllables in terms of pitch, timing and articulation that were not considered when the child sang for the first time. Only two syllables and the individual features of them correspond to the teacher's model (marked as white boxes). Thus, the syllable 'jun' was sung in the correct pitch, and the syllable 'choo' was articulated properly. How the analysis of the syllables' pitch, timing and articulation was achieved is described in detail in the next section, which provides micro-analyses of these properties.

Analyzing of Data – Time Analysis of the Onset of the Syllable

Temporal analysis entails comparing the temporal organisation and synchronisation of a child's song syllables with those of the teacher. To achieve this, both audio recordings were uploaded into Audacity software and compared with each other. Audacity is a free and open-source digital audio editor and recording software. It shows sung syllables along the timeline and offers the opportunity to multi-layer multiple audio data. Using this graphical representation of the sound produced during singing, it is feasible to determine the moment when the child initiates singing and whether they start singing simultaneously with the teacher or experience a delay (see Figure 6). The teacher's singing represents the model and gives the onset signal. If the child sings at the same time as the teacher, the syllable onset times match. If there is a delay between the teacher and child singing, the signal is classified as offset.
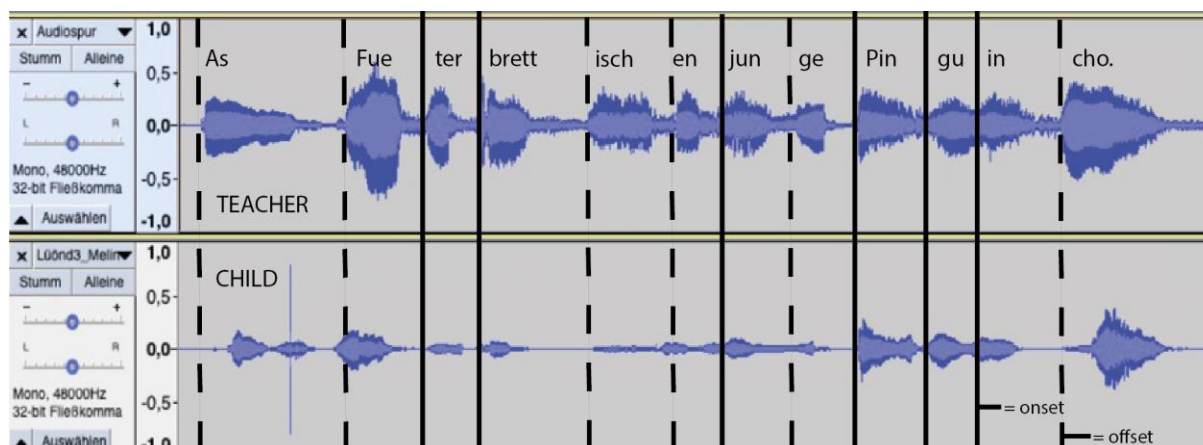

Figure 6. Audacity Visualises the Teacher and the Child's Singing and the Matching and Mismatching Syllable Onset.

Figure 6 illustrates how the teacher's sung syllables (top) and those of the child (bottom) are superimposed to identify the onset and offset of the syllables. If the signal is triggered at the same time, both participants sing synchronously. If the signal is displaced, the child's sung syllable is asynchronous, and therefore offset. The example in Figure 6 features the singing of six syllables onset and six syllables offset. Another example is given in Figure 7, which shows the teacher's singing (top line) in comparison to Kira singing for the first time (bottom line). In contrast to the analysis in Figure 6, here, the child's sung syllables appear blurred. Kira sings the syllables legato-like, without any clearly identifiable onset of the syllables. As a result, no syllables of this first phrase are detected as onset (see, correspondingly, Figure 5).
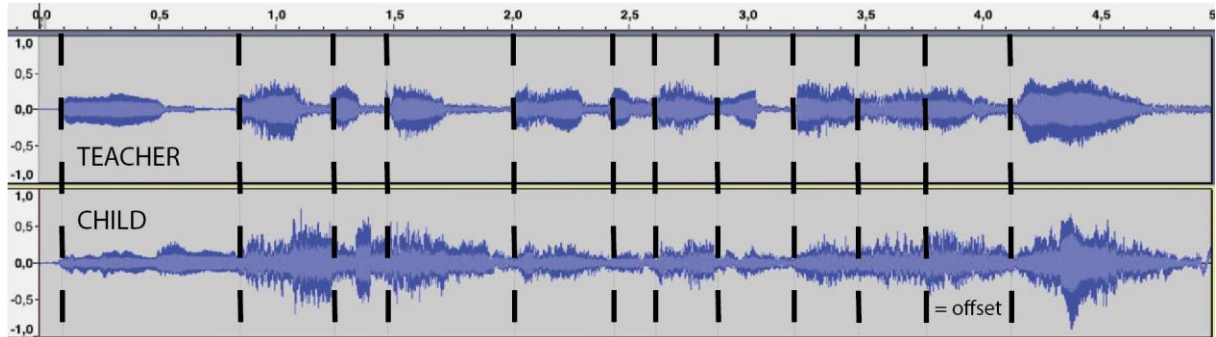

Figure 7. Audacity Reveals the Different Temporal Aspects (onset and offset) of the Teacher and Kira, who was Singing for the First Time.

Analyzing of Data – Pitch Analysis of the Syllable

With regard to the tonal analysis, the child's sung pitch was analysed and compared with the teacher's model. For the analysis of the sung pitch, a tonal system or framework was needed. Therefore, the orientation lay on the octave and its equal division into 12 units or categories representing well-tempered tuning in Western musical culture. An octave with 12 semitone steps corresponds to a pitch range of 1200 cents (i.e., 100 cents per semitone). Described in the comparative study of pitch-analysing programs (Devaney, 2020), this subdivision is generally used in different types of software (e.g., Tony or Melodyne). Due to its ability to accurately detect and visualise breathing and consonants, Melodyne was selected as the software of choice. The software converts mp3 recordings into the different pitch frequencies thanks to an algorithm. The vocal line is shown as a graph. The sung syllables are represented in Figure 8.
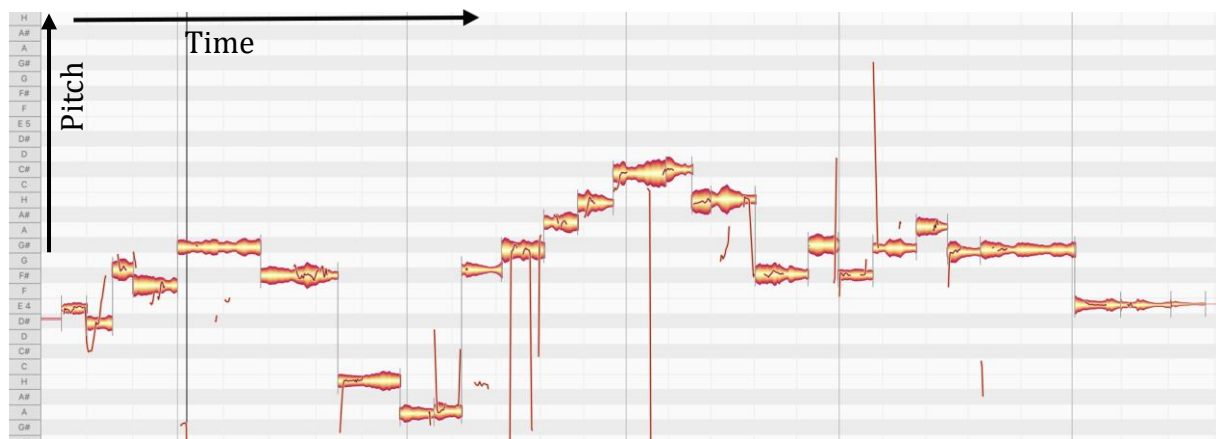
Figure 8. Example of Melodyne Software Analysis of Kira Singing for the First Time.

Melodyne shows on the x-axis the timing, and on the y-axis the pitch (Figure 8). The average pitch of a segment is calculated from its micropitch curve, which represents the progression of the pitch (Zadig et al., 2016). Melodyne determines the pitch of a particular syllable and presents the corresponding note name, along with its deviation from the standard pitch in cents. This value is then entered into a table and compared with the song model. If the pitch does not deviate from the model by more than 50 cents, the sound is considered to have been intonated correctly. According to other research on scoring accuracy for single pitches, Pfordresher and Demorest (2020) considered any absolute difference greater than 50 cents an error. In summary, Melodyne was used to analyse the tonal aspects of the children's singing; that is, to determine the accuracy of the syllables sung and thus whether the syllables had been produced within or outside the 50 cent deviation.

Analyzing of Data – Articulation Analysis of the Syllable

By listening repeatedly to the children's audio recordings, the lyrics were examined by evaluating the quality of the articulated syllables (vowels and consonants) to determine whether the syllables were reproduced recognisably; that is, whether the vowels and consonants were articulated equally clearly or if the syllables were reproduced indistinctly with elongated vowels.
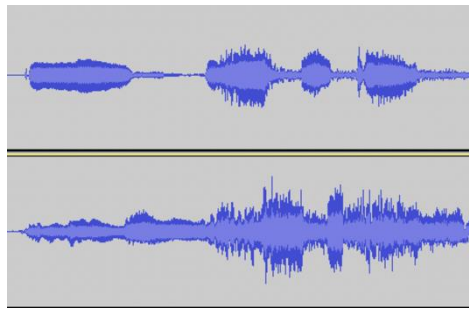

Figure 9. The Top Line Shows an Example of Four Syllables Clearly Articulated by the Teacher, which is Compared to the Blurred Articulation by the Child on the Bottom Line.

Audacity software is used for multiple listening. The visualised audio signals are also helpful for recognising articulation. If a syllable is clearly articulated, it is visually recognisable as a clearly delineated single syllable and separated from others by a short moment of silence—a category with boundaries. If the syllable is not clearly articulated, it can be seen as a syllable without contour and clear separation (see Figure 9). Having presented the approach for the analysis of children's singing, with regard to the timing, pitch and articulation of the syllable, what follows next is the integration of these three levels into the analysis and evaluation of the three children's singing in relation to each other as well as to the teacher's song model.

Data Analysis and Evaluation of the Three Children's Singing

The method just described is now applied to study a specific lesson and the teaching and learning of a new song. The lesson was taught by Verena, a pre-service teacher in her final year of training who was familiar with the class from her previous internship. The focus of the lesson was on the theme of the South Pole and penguins, and so Verena selected a new target song solely according to this theme and based on her own choice. On the part of the researchers, we only required the song to be unfamiliar to the children. Verena's third lesson lasted 30 minutes, and seven children participated in the class. Three of them—Kira, Mia and Klara—volunteered to wear a microphone and thus were the participants of this study.

To study the process of song acquisition in the context of joint singing during a lesson, an overview of the actions performed during the lesson is required, in the form of the LAMap. The LAMap of this particular lesson (Figure 10) shows that the teacher sang the song four times before she asked the children to sing. While the teacher was singing, the children walked through the kindergarten like in a row penguins, listening to the song. The second time, by analysing the individual microphones of the children, it could be seen that they spontaneously hummed along with the teacher, even though they had not been instructed to do so; the children did it voluntarily and intuitively. After singing the song twice, the teacher changed the task; the children were allowed to move freely, but when the song stopped, they had to stop immediately. The teacher played this game twice. It is noteworthy that within just a few repetitions, the children began to reproduce certain words, primarily nouns, and made attempts to sing along with the song, albeit without any explicit instruction to do so. During the scene in which the teacher paused before the last syllable, it so happened that one of the children, Mia, sang the correct syllable at the correct time. This demonstrates nicely how salient features of the song, such as endings of phrases, including rhymes, were already in some of the children's minds after a short time. After Verena had sung the song four times to the children as an introduction, she asked the children to sing along with her. The LAMap shows that she sang only one of three verses of the song and sang this song as a whole, as well as parts of it (LAMap, Figure 10, second and fifth singing, shown as part of the song). The teacher accompanied the children with the guitar and used other aids, such as puppets or pictures. The children sang the song a total of 11 times, and the methodology outlined above was employed to analyse these singing activities. Considering that describing all 11 singing sessions with Kira, Mia and Klara would be beyond this article's scope, I have limited myself to three sessions: the first singing, the sixth singing and the last joint singing (see Figure 10). In this way, the process becomes clear, since the beginning, middle and end of the singing are made visible. Next, the analysis of the three reproductions of each of the three children is represented by using the methodology introduced above.
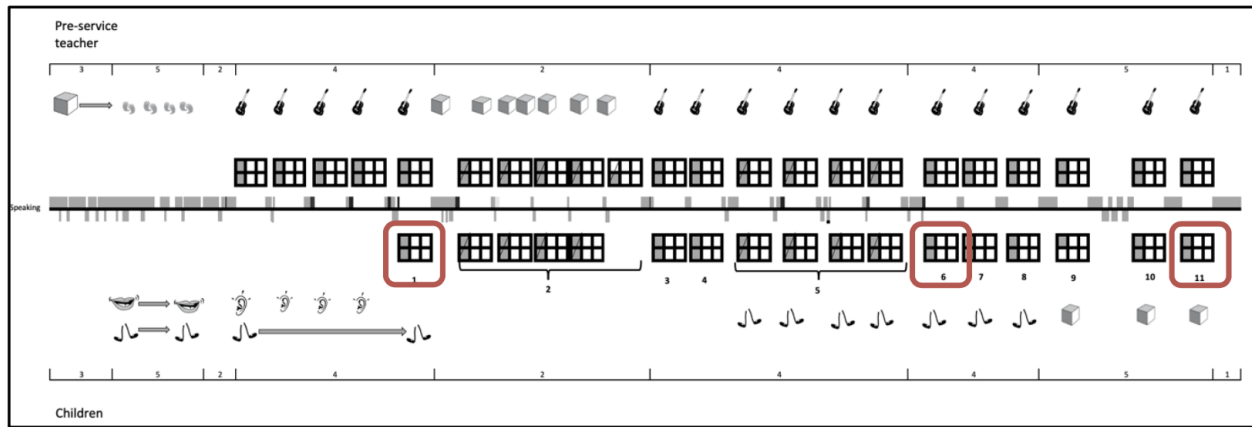
Figure 10. The LAMap of the Lesson Taught by Verena with the Three Marked Singing Events.

KIRA (Child 1; Figure 11 Provides an Overview of the Three Singings, A, B, and C)

First Singing: Notably, Kira's singing of the first syllable 'as' is delayed, followed by the three subsequent syllables 'Fueter-brett' (Figure 11A). She then sings the stressed first syllable of 'jun-ge' and the stressed first two syllables of 'Pin-gu-in' but omits the final syllables (-ge and -in). After singing the last syllable of the first phrase 'choo', which she articulates well, but with incorrect pitch and timing, Kira then pauses from singing for seven syllables. Only at the noun 'zoo' does she sing again, and this is delayed and with an unstressed pitch. In phrase 2, the only syllable matching the model and the pitch is 'voo', the last syllable of the phrase. She omits unstressed syllables, such as 'de', at the beginning of phrase 3. This phenomenon also occurs in phrases 3 and 4. Notably, at the end of each phrase, Kira sings along. After another major gap, she sings the final syllable, the song's keynote, at the correct pitch, but it is delayed and indistinctly articulated.

Sixth Singing: Kira does not sing the up-beat, but she sings the noun 'Fueterbrett' with the correct timing. The timing and pitch of the word 'pinguin' are correct, but the articulation remains unclear. In the middle section, new syllables are added, but again, her syllables are poorly articulated; nevertheless, she audibly reproduces sounds (Figure 11B).

11th Singing: Kira sings along with the up-beat, which is slightly delayed but on the correct syllable with the appropriate pitch. The opening 'As Fueterbrett' is now clear in terms of pitch and articulation. This can be affirmed to the extent that Kira reproduces this beginning independently in class. An analysis of the audio data reveals this additional singing by Kira after the ninth joint singing. It appears that Kira sings the first four syllables of the song with a distinct pitch, with accurate lyrics and the correct melody, while the teacher gives instructions to the class. (The presence of this singing came to light only during the analysis of the individual microphones. It went unnoticed during the analysis of the lesson and the conception of the LAMap.) In phrase 4, we can see that the syllables 'Zwee Fische bstellt' are clearly recognisable. The beginning and the end are, with few exceptions, the only places where the syllables are clearly articulated (i.e., consciously sung by the child; Figure 11C).

Figure 11. The Three Song Reproductions (A, B, C) by Kira

MIA (Child 2; Figure 12 Provides an Overview of the Three Singings, A, B, and C)

First Singing: Mia does not sing the up-beat and instead enters the first singing with the noun 'Fueterbrett' late, but with the correct pitch (Figure 12A). She omits syllables mostly in phrases 2 and 3 (i.e., in the middle of the song), and she reproduces all the syllables positioned at the ending of the phrases. However, the syllable pronunciation is blurred, and the timing of 'cho' is delayed. After four omitted syllables, 'zoo devo' is the next noun, followed by a rhyme on 'cho'. After a longer pause, Mia joins in with 'zelt', the final syllable of phrase 3 and the rhyme, which then ends with 'het bim Spatz

zwee Fische bstellt'. She audibly sings a total of 22 syllables (out of a total of 38), many of which are poorly articulated and delayed.

Sixth Singing: Mia has not yet sung the initial syllable, but immediately thereafter, 'Fueterbrett' is sung at the correct pitch, clearly articulated and corresponding to the pulse (Figure 12B). The entire first phrase is already internalised, except for the last phrase syllable 'cho', which is still rendered with a delay. In the second phrase, the up-beat is not present, and several words (e.g., 'vom') are missing. Furthermore, the chromatic passage 'zoo de-vo' is not intoned cleanly, and subsequent syllables are also not tuned correctly, possibly because the preceding chromatically rising sequence of tones means that the basic tonality is no longer clearly recognisable for the child. Two syllables are omitted, possibly because the beginning and ending of phrases are usually more prominently marked by linguistic (thymes), temporal (stress) and musical (keynote) features, and thus, may be easier to recollect. In phrase 4, Mia sings all the syllables. In particular, the last four syllables correspond to the model at all three levels.

11th Singing: Mia sings clearly and with a mostly stable pitch from the beginning. Many words, including nouns, are already there, but two parts are still not, according to the model. That is, 1) the preceding eighth note (the syllable 'choo') is still offset, asynchronous to the model, and 2) the chromatic passage is also unstable in pitch until the end (Figure 12C).
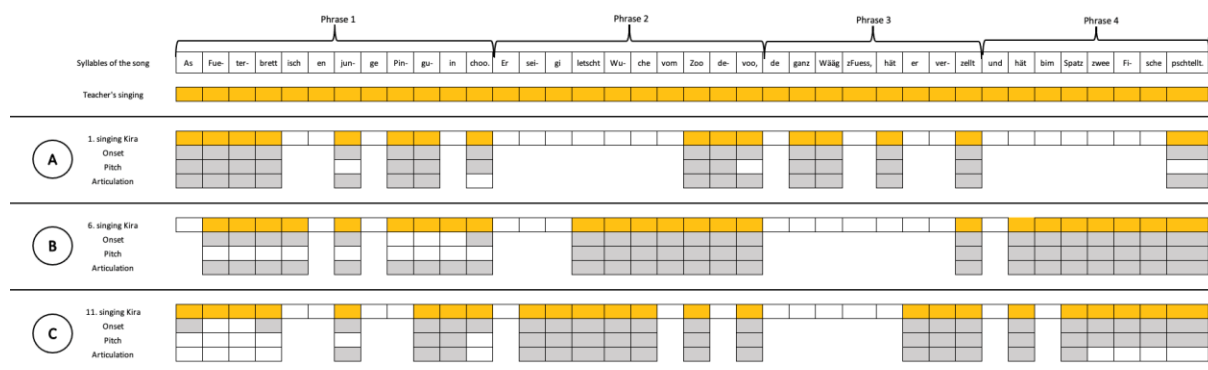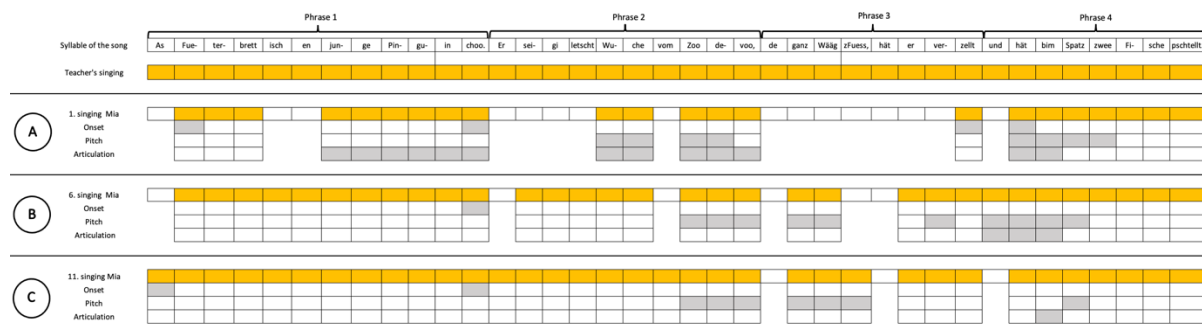

Figure 12. The Three Song Reproductions (A, B, C) by Mia

KLARA (Child 3; Figure 13 Presents an Overview of the Three Singings, A, B, and C)

First Singing: When singing for the first time, Klara notably sings the first syllable, 'as', in synchrony with the teacher. The syllable is not articulated clearly, and the pitch also does not correspond to the model, but the temporal aspect, the onset time, is already produced here. In producing the word 'Fueterbrett', Klara omits four syllables. Only with the next word, 'pinguin', does the child re-join the singing. The first syllable is articulated clearly, and the timing and pitch are also correct. This is the first syllable in Klara's singing in which all properties are met, possibly because this word is the denotation of the animal that was discussed explicitly at the beginning of the lesson. Subsequently, the sung syllables alternate with omissions. Klara's singing is mostly poorly articulated and legato, but two exceptions should be noted. First, concerning the syllable 'voo', which forms a rhyming couplet with the preceding word 'choo' and is positioned at the end of the phrase, Klara sings it onset and with clear articulation, but the pitch is poorly intonated. Although this final syllable in particular is marked linguistically as a rhyme, the pitch does not correspond to the model. Second, the last three syllables, 'Fi-sche bestellt', are the only places in Klara's performance, aside from 'penguin', in which a whole word is articulated, and thus is intelligible. In addition to t this word denoting the animal discussed in the lesson, the song ends on the root note, making it easier for the child to sing this pitch (see Figure 13A).

Sixth Singing: An interesting phenomenon was heard on the recording at this point. Klara counted to four, mimicking the counting time that the teacher used (Figure 13B). Despite counting along, Klara does not sing the first syllable, 'as'. Compared with the first song, she now sings much more clearly articulated syllables, which were also simultaneously correct in time. Notably, exactly two syllables meet all three properties correctly: the last syllables of 'Fueterbrett' and of the verse 'pschtellt'. Both are the song's keynotes, suggesting that Klara is following the respective tonal rules.

11th Singing: On the final singing, it is nice to see that Klara has already reconstructed the song during the joint singing. She sings the first syllable and phrase completely, with only slight deviations from the melody (see Figure 13C). The transition into joint singing succeeds, and Klara sings the syllable 'as'. Both the melody and lyrics are clearly recognisable, and the syllables are correctly articulated. However, Phrases 2, 3 and 4 are not rendered as accurately. Compared with the sixth singing, some syllables that have been sung before ('bim Spatz') are missing here. Compared with the sixth singing, Klara sings the final three syllables with the correct pitch, the correct timing and the correctly articulated syllable. The number of syllables sung has increased, and between her sixth and 11th reproduction, as further improvements, other passages are sung with clear articulation.
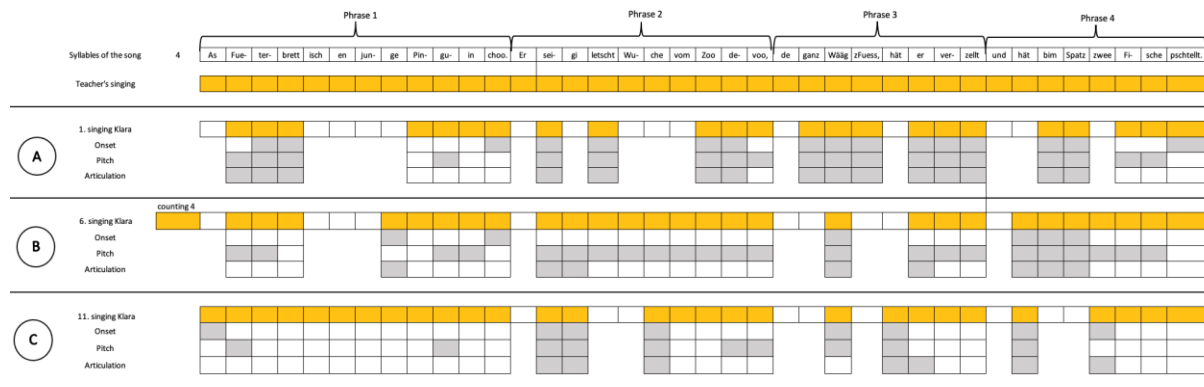
Figure 13. The Three Song Reproductions (A, B, C) by Klara

Comparison of the Three Children's Last Song Reproduction

The microanalyses of the song reproduction of the three children have so far shown that the number of sung syllables increased for each of the children. Figure 14 provides an overview on the last reproduction to facilitate a comparison. In this 11th singing, all children sing the first note 'as', although all of them do so with it offset and delayed. The last phrase with the pitch ending on the keynote is produced by all three children and two out of three do so at the correct pitch, in time and with good articulation. In this 11th sung version, by the end, of all the 38 syllables, Mia sings 35 syllables, Klara 29 and Kira 24. Mia's syllables are of consistently high quality, with only occasional deviations from the model, as indicated by the 10 grey marked boxes. On the other hand, Klara has 25 grey marked syllables and Kira 54, indicating that their performances were not as strong as that of Mia. Based on this, it can be inferred that Mia coped best with the song and the rules, Klara came in second and Kira had most problems in following the rules and the song.

Remarkably, there were some regularities. The children did not sing the beginning of each phrase, except for the very first syllable, whereas all the endings of the phrases were sung. Another regularity in all three cases was the poor intonation in the second phrase. Here, all three children failed to sing correctly the chromatic passage.
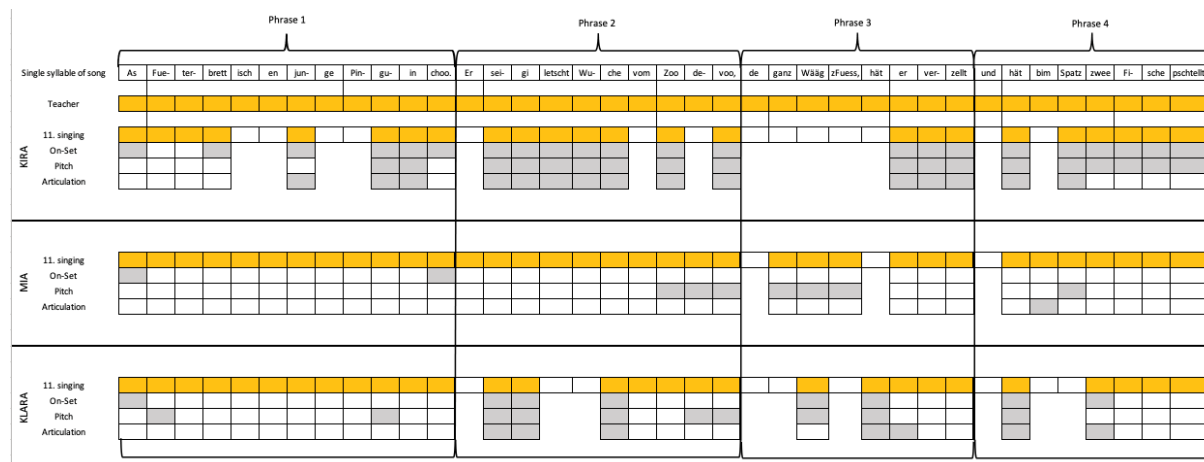

Figure 14. Overview of the Last Singing of the Three Children, Kira, Mia and Klara, at the End of the Lesson (See LAMap, Figure 10)

These findings are the result of the microanalytical analyses of the three children. The ease as well as the difficulties they expressed while acquiring this song have to be seen in relation to how the target song was composed. With each song that the children learn, they also become familiar with the underlying singing rules. Songs that follow simple rules with respect to the lyrics, melody and timing are easier to acquire than those with complex rules, such as a change of keys or syncopates. An analysis of the learning object (i.e., the rules of the target song) is a constitutive aspect of the didactic reconstruction of the teaching–learning process. The analysis of the song using the grammar of songs for children will contextualise the findings into a rule-based framework.

Grammatical Analysis of the Target Song

The target song chosen by the teacher can be analysed from a grammatical viewpoint. Songs for children follow basic lyrical, timing and tonal rules that ideally yield a well-formed entity (Stadler Elmer, 2021). The grammar consisted of seven general properties and 21 rules based on the Western tonal system, which refer to tonal, temporal and linguistic components. This grammar was subsequently used to analyse to the target song 'Pinguin am Fueterbrett' (see Figure 15)

in order to make explicit the rules on how syllables and their features are combined to create a song for children. The grammar of songs for children, by focusing on elementary rules, helps identify exemplars of this genre, and thus also identifies non-exemplars. In case the rules of a song are no longer elementary, it does not belong to the typical genre of songs for children.

Figure 15. The Song 'Pinguin am Fueterbrett', the Target Song Selected and Presented by the Teacher. Bond (1998, p. 28)

Timing rules: The song comprises a 4/4 bar and begins with an up-beat. The rhythm comprises quarter and eighth notes. The notes are notated as binary, but the same song is sung in swing ternary on the corresponding commercial recording. In measure 2, an eighth note is brought forth, creating an anticipation and interrupting the regular pulse. Furthermore, in measure 8, an eighth note is brought forth, again creating an anticipation and interrupting the regular pulse.

This rhythmic anticipation does not conform to the grammar rules of songs for children because it deviates from the simple rules (e.g., all syllables are metrically timed and bound to a note). Hence, no tones and syllables should lie outside of the established meter or violate the even number of measures (Stadler Elmer, 2015). The division of bars into different phrases is common (i.e., the song consists of four phrases of two bars each). The phrase forms the temporal frame in which the text and melody are synchronised simultaneously (Stadler Elmer, 2015). For example, the beginning and end of the verse lines and phrases are marked linguistically by the rhymes at the ends of the lines and musically by the reference to the keynote in particular (Stadler Elmer, 2015). If we compare these findings—the manner in which the target song deviates from basic song rules—with the children's singing, two points become apparent. First, in the second phrase, the eighth note is noted as an anticipation. The analysis of the children's singing showed that two out of the three children, even in the last version, did not reproduce this anticipated syllable with the correct timing, but with a delay. The children might have had difficulty with the interrupted regularity of the pulse of the song. Second, none of the three children sang the upbeat in phrases 3 and 4. By analysing the song, the upbeats of the phrases are different and asymmetrical and do not conform to the grammar of songs for children, which seek symmetry. In phrase 3, the upbeat is a quarter note, whereas the other upbeats are written as eighth notes. This irregularity in the composition may be irritating and can thus explain why the children did not sing this up-beat, despite its rhythmic simplicity. Furthermore, two of the three children also missed singing the upbeat of phrase 2. This missing link between the phrases may be attributed to the fact that the teacher presented the phrases separately during class (see LAMap, 2nd and 5th singing). This could be a reason why the transitions between the individual phrases had not yet been solidified.

Tonal rules: The song is written in E-major—major keys are common in children's songs. The starting and ending pitches are the key tone, but two passages of the song are atypical for a children's song; in the second measure, the alternating note f#–f–f# introduces a note that is foreign to the scale. Thus, the tonal framework is abandoned at this position. Furthermore, in measure 4, with the addition of the note a# as a chromatic passing note, the basic key is left again. This addition of two non-scale tones deviates from the basic rules that constitute the genre of songs for children, in which the melody is limited to the tones that all belong to the same major or minor scale (Stadler Elmer, 2015). If we compare again these findings with the children's singing, the non-scale tones in the song were remarkable in the children's singing. Kira and Klara both struggled with the change from f# to f and back to f# in the first phrase ('pin-gu-in'). Although most of the syllables of this phrase were sung, this specific section seemed problematic to the two children, since their sung pitch deviated from the model. Even more obvious were the tonal difficulties at the end of the second phrase in 'Zoo de-vo'; here, none of the children arrived at intonating the pitch correctly, and all three children sang this chromatic passage unclearly and unstably.

Linguistic rules: When voicing the text rhythmically, the stress pattern is notably irregular. That is, the natural word stress (e.g., 'pinguin') and the melody's meter do not match. In this example, the text is superimposed on the melody, and

the linguistic and musical rules are not combined in a well-formed way. The syllables' accents in the word 'pinguin' do not match the accents of the musical meter. Once again, this is a deviation from the simplicity of the grammatical rules of songs for children. One rule states that the stresses of the syllables in the words should correspond to the musical meter. Stressed syllables match stressed melody notes, and likewise, unstressed syllables match unstressed melody notes. This is not the case in the target song.

In summary, by comparing the results from the analysis of the children's singing with the grammatical analysis of the target song, it is evident that the children had difficulty just in those passages where the song deviates from the basic timing, tonal and linguistic rules. These deviations caused difficulties even until the end of the lesson. It can be asserted that the song selected by Verena, the teacher, was not appropriate for singing with kindergarten children.

Discussion

First, the method provides visual information not only about a child's sung syllables with respect to pitch quality but also about the timing and articulation. This perspective allows us to account for a song as a complex combination of melody and lyrics. Moreover, each sung song is represented next the song model, which makes it possible to follow graphically the child's syllable omissions and additions during song learning. Comparing the song model and a child's reproduction of it during a lesson gives insights into the learning process in terms of changes. Since individual children's singing was analysed, it is possible to compare several of the children's song reproduction, and thus to gain information about how the children coped in this particular lesson, with the teacher and the new song.

Second, the results show the importance of conceiving the syllable as both the basic element of a song as a model and a unit for the analysis of song production. Only with reference to the syllable and its features (pitch, timing and articulation) does it become possible to analyse the song as the target teaching object and, correspondingly, the learners' reproductions throughout the lesson. The novel approach of subdividing a song into its syllables and analyzing these sung syllables in terms of pitch, timing, and articulation represents a previously unexplored methodology. By showcasing how children individually sing a syllable or a song in class and tracking their singing throughout a lesson, this novel approach offers an important innovation in comprehending the process of song acquisition among children. It enables a deeper understanding of how their singing develops over time, shedding light on this crucial aspect of their musical education. We devised this methodology to gain access to the triple relationship between the song as a teaching object and how the children cope with the teacher instructing the song. It is an example of subject-related didactic research because the methodology is tailored to the subject—the musico-linguistic unity of song—and the teacher's and children's related reproductions. As the goal of the teaching was to transmit a new song, both the LAMap and the analysis of singing gave insights into how this had been achieved.

Third, the grammatical analysis of the song model allowed us to reconstruct the structural problems in the song composition and to relate them with the difficulties the children expressed while learning the song. It is remarkable to make explicit the rule deviations in the song (e.g., the use of notes outside the scale) to break the symmetry of the phrases or to use incompatible stress patterns in the melody and the lyrics. It is also remarkable to juxtapose the rule deviations in the model song with the children's reproduction. By doing so, the difficulties that the children had in learning the target song became evident as being strongly related to the grammatical problems in the song in terms of rule deviations.

Conclusion

The findings of this research illustrate how children collectively sing a new song in a lesson guided by a teacher, how they improve their reproduction and how they struggle with the grammatical rule deviations in a model song. To analyse and describe in detail these didactic processes of teaching and learning, the design of a tailored methodology was necessary. Whereas singing is often analysed only with respect to pitch accuracy, we used the syllable and its features as the basic element of the model song and as the unit of analysis. Our goal was to describe the complex dynamics between the teacher and children while a new song is being taught and learned and to improve our understanding of the didactic processes. This study exhibits innovation by examining the singing of individual children throughout a class lesson, thereby providing insights into their singing processes. A major outcome is the remarkable correspondence of the children's problems in singing with the rule deviations of the target song. The demonstration of this analytical method should encourage further examination of this complex structure of interaction among the teacher, the learner and the object to obtain a variety of song-learning processes and a subject-related reconstruction.

Recommendations

This article shows a method to investigate and analyze the individual voices when singing together. It would be useful to also microphone other children in other classes and examine their singing. It is important to consider the specific song being sung when examining the challenges faced by children and determining if these challenges align with the grammar of the song. In the coming years, this new method of analysing single singing in class has the potential to serve beyond scientific analysis and dissemination by integrating into teacher training and ongoing education programs. In addition, this method facilitates the selection of suitable songs, because when analyzing the children's voices, it becomes clear

where and whether the children have difficulties with a song or whether it is easy to sing. Especially in teacher training this aspect could be a support.

Limitations

At the present stage of development of this method of analysis of individual voices, it is discussed how to record the individual singing of children even better. The microphones sometimes fell down when the children moved and distracted them, especially in the beginning. This should be considered in the next data collection.

Acknowledgements

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