AcaMate: Supporting Novice A Cappella Singers in Iterative Individual Practice

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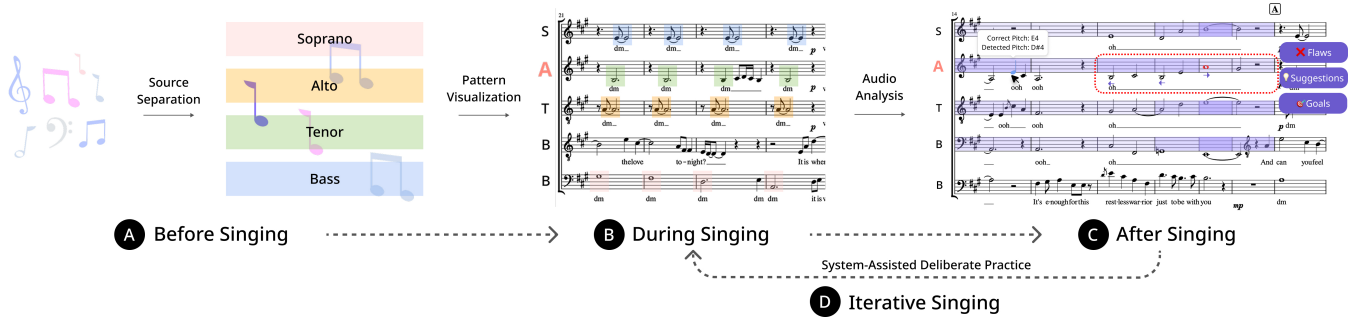University of Michigan
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Figure 1: Workflow of AcaMate. Users iteratively practice during an individual A cappella rehearsal. Before singing (A), AcaMate separates the group recording into different voice parts, allowing users to create flexible and authentic mixes. During singing (B), AcaMate highlights musical patterns to help users perceive relationships between their part and others. After singing (C), AcaMate delivers intuitive feedback on pitch, rhythm, and dynamics. To facilitate iterative practice (D), AcaMate analyzes weak segments, offers suggestions, and sets practice goals for users.

ABSTRACT

Novice singers in collegiate A cappella groups often struggle with individual practice due to limited guidance and the challenges of asynchronous rehearsal. We propose AcaMate, a system designed to support individual practice by integrating group recordings, visualizing musical patterns across voice parts, and providing intuitive feedback to guide iterative and deliberate practice.

CCS CONCEPTS

• **Applied computing → Sound and music computing**.

KEYWORDS

A cappella, feedback, music visualizations, deliberate practice

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1 INTRODUCTION

A cappella is a music genre performed without instruments, relying solely on the human voice and body [11]. It has become increasingly popular among college students [4]. In the 2025 Varsity Vocals International Championship of Collegiate A Cappella, 7,200 performers participated across 445 collegiate groups [12]. Compared to other group music like choral ensembles, collegiate A cappella groups are typically smaller and do not have a conductor [3]. Students rotate through roles like soloist, arranger, and music director [1, 6]. With this peer-led structure, collegiate A cappella groups remain democratic, providing students with valuable learning opportunities to practice music-making and collaboration [1, 3, 6].

However, it's challenging for collegiate A cappella groups to access professional guidance. Many groups include novice singers without formal musical training, and some groups are non-auditioned, meaning members may have little singing experience [6]. Rehearsals are typically led by more experienced peers—often students in music-related majors [1]. However, the feedback they provide can be limited or even inaccurate [6]. The lack of professional guidance is a persistent challenge during individual practice, where singers rehearse independently and asynchronously to internalize their parts. Individual practice is crucial for improving group rehearsal efficiency and helping absent members catch up. However, practicing alone can be especially difficult for novices, who often struggle without external guidance. As a result, additional support is needed to guide novice A cappella singers during individual practice.

While tools like MuseScore[1] provide synthesized audios aligned with sheet music, they lack the vocal context of the singer's group,

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[1]https://musescore.org/

making them less effective for practice. Some commercial tools—VoceVista Video[2] and Sing & See [2]—and prior research [5, 7, 10] have explored offering real-time visual feedback on features such as pitch, timbre, and breath. While informative, these real-time visualizations can impose a high cognitive load on novices, who may find them overwhelming or abstract to interpret. Although Soloist [14] delivers tailored feedback and progress tracking for beginner guitarists, it focuses on solo practice and does not support the collaborative nature of A cappella singing.

To address novices' need for guided individual A cappella practice, we propose AcaMate (Figure 1), a novel system designed to scaffold context-aware, strategic, and deliberate practice. AcaMate enables novices to practice with their group recording by separating voice parts before singing, allowing them to adjust and mix parts. During singing, AcaMate visualizes musical patterns to help novices understand how their part aligns with the group. After singing, AcaMate provides feedback on pitch, rhythm, and dynamics, and highlights weak segments. To encourage deliberate practice, AcaMate analyzes mistakes, offers suggestions, and defines goals for iterations. Novices can retake recordings and track their progress toward reaching the goals.

2 PROPOSED SYSTEM DESIGN

In this section, we introduce design goals and key features of AcaMate by walking through the stages of an individual rehearsal.

2.1 Design Goals

Drawing on existing literature, discussions with novice A cappella singers about their challenges, and the authors' own experiences, we identified the following design goals (DGs):

DG1: Provide authentic vocal context by integrating the singer's own group recordings into individual practice. A cappella parts are rhythmically and harmonically interdependent, so singers rely on each other's vocal cues to stay synchronized. Practicing alone, novices often struggle to understand how their voice fits within the group. Therefore, DG1 aims to recreate the group rehearsal context in individual practice by incorporating group recordings.

DG2: Offer intuitive, context-aware feedback to help singers interpret self-performance and understand alignment with other parts. In group rehearsals, peers quickly spot issues and exchange feedback. Practicing alone misses such opportunities. Novice singers must self-assess and track progress independently, which is difficult: many struggle to evaluate their own voices accurately [8] and often fail to improve just by listening to themselves [13]. DG2 aims to provide intuitive, actionable feedback to help singers identify weaknesses and understand how their part fits within the group.

DG3: Enable guided and flexible creation of deliberate practice with adaptive feedback. A cappella rehearsals involve dynamic practice strategies. For instance, interdependent accompaniment parts sharing similar rhythmic patterns may rehearse together. Practicing alone, novices cannot recreate these rehearsal practices. DG3 thus aims to guide novices to initiate targeted and iterative practices.

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[2]https://www.vocevista.com/en/

2.2 System Features

2.2.1 Before Singing: Voice Part Preparation.
AcaMate separates the group recording into voice parts and aligns each part's audio with the sheet music. Novices can listen to separated parts while following along on the interactive score, supporting **DG1** by bringing the group context into solo practice. Additionally, novices can create custom mixes by freely combining any subset of parts or selecting any segments to focus on, supporting **DG3**.

2.2.2 During Singing: Musical Pattern Highlight.
Following **DG2**, AcaMate, instead of providing real-time acoustic feedback, highlights musical patterns commonly found in A cappella that involve the user's part, including homophony, call-and-response, layered entrances, and rhythmic interlock [15]. These patterns are visualized with different background colors on the score to help novices perceive relationships between their part and other parts.

For homophony, notes belonging to the same chord are grouped within a colored block, with the color's shade deepening along the chord progression to indicate harmonic movement. Call-and-response patterns use contrasting blue and red backgrounds to emphasize dialogue between parts. Layered entrances are marked by a rainbow-ordered color scale to show the sequential entry of each part. Rhythmic interlock is visualized with complementary color pairs to highlight rhythmic interplay between parts. Hovering over the visualization will reveal an explanation of the pattern.

2.2.3 After Singing: Visual Feedback on Pitch, Rhythm, Dynamics.
After singing, AcaMate analyzes the recording and visualizes feedback on pitch, rhythm, and dynamics, aligning with **DG2**. These features, especially pitch and rhythm, are critical in A cappella, where the absence of instrumental accompaniment removes external reference points [11]. For pitch, notes are color-coded: blue for flat, red for sharp, green for correct, and black for unvoiced. Novices can hover over a note to view its target pitch and detected pitch. For rhythm, arrows appear next to notes with timing errors: a left arrow shows the note was sung early, while a right arrow indicates it was late. To represent dynamics, the average volume of each measure is visualized by adjusting background color transparency: more transparent backgrounds signal softer dynamics. Novices can also enable visual feedback for other parts to check group alignment.

2.2.4 Iterative Singing: Deliberate Practice of Weak Segments.
Following the key elements of deliberate practice—targeting specific movements, analyzing flaws, defining goals, and retrying with goals [9], AcaMate identifies segments where novices performed poorly based on pitch, rhythm, and dynamics. It then explains specific mistakes and offers actionable suggestions, such as "mute the bass part," which novices can choose to apply. Next, AcaMate sets targeted goals related to rhythm, pitch, or dynamics and visualizes progress toward each goal with progress bars. With these feedback, novices can loop back to the "During Singing" stage to deliberately practice weak segments, aligning with **DG2** and **DG3**.

3 CONCLUSION & FUTURE WORK

In this project, we introduced AcaMate, a novel system designed to support novice A cappella singers during individual practice. While AcaMate is tailored for the A cappella context, its workflow and iterative deliberate practice features are broadly applicable to other

collaborative singing scenarios, such as asynchronous ensemble rehearsals. More generally, ACAMATE supports audio-based communication by enabling users to manipulate recordings, understand interrelationships between audios, and analyze both their own and others' voices. In future work, we plan to conduct longitudinal studies with A cappella groups to assess the system's impact on learning and communication, and to derive broader design implications.

REFERENCES

[1] Jacob Berglin. 2015. "It's Much More Collaborative": Democratic Action in Contemporary Collegiate A Cappella. (2015), 51–69. https://doi.org/10.5406/bulcouresmusedu.205.0051

[2] Jean Callaghan and Pat Wilson. 2004. *How to Sing & See: Singing Pedagogy in the Digital Era*. Lulu.com. Google-Books-ID: A5kcAgAAQBAJ.

[3] Joshua S. Duchan. 2007. Collegiate a Cappella: Emulation and Originality. *American Music* 25, 4 (2007), 477–506. https://doi.org/10.2307/40071679

[4] Joshua S. Duchan. 2012. *Powerful Voices: The Musical and Social World of Collegiate A Cappella*. University of Michigan Press. Google-Books-ID: kLC0VxIKy8sC.

[5] S. Ferguson, A.V. Moere, and D. Cabrera. 2005. Seeing sound: real-time sound visualisation in visual feedback loops used for training musicians. In *Ninth International Conference on Information Visualisation (IV'05)*. 97–102. https://doi.org/10.1109/IV.2005.114

[6] Marshall Haning. 2019. "Everyone Has a Voice": Informal Learning in Student-Led Collegiate A Cappella Ensembles. (2019), 61–76. https://doi.org/10.5406/bulcouresmusedu.219.0061

[7] Mattias Heldner, Marcin Włodarczak, Peter Branderud, and Johan Stark. 2019. The RespTrack system. In *1st International Seminar on the Foundations of Speech: BREATHING, PAUSING, AND THE VOICE, Sønderborg, Denmark, 1-3 December, 2019*. 16–18.

[8] S. Leong and L. Cheng. 2014. Effects of real-time visual feedback on pre-service teachers' singing. *Journal of Computer Assisted Learning* 30, 3 (2014), 285–296. https://doi.org/10.1111/jcal.12046

[9] Karen Ludke, Carol Beynon, Helga Gudmundsdottir, and Annabel Cohen. 2020. *The Routledge Companion to Interdisciplinary Studies in Singing, Volume II: Education*.

[10] Filipa M. B. Lã and Mauro B. Fiuza. 2022. Real-Time Visual Feedback in Singing Pedagogy: Current Trends and Future Directions. *Applied Sciences* 12, 2121 (Jan. 2022), 10781. https://doi.org/10.3390/app122110781

[11] N. Lindsay Norden. 1936. A New Theory of Untempered Music: A Few Important Features with Special Reference to "A Cappella" Music. *The Musical Quarterly* 22, 2 (1936), 217–233.

[12] Andrew Poole. 2024. Your 2025 ICCA Lineup. https://varsityvocals.com/2025_icca_lineup/

[13] Inge E. Southcott and Helen F. Mitchell. 2020. How singers hear themselves: Using recordings in the singing studio. 15 (Aug. 2020), 20–28. https://doi.org/10.3316/informit.237065737543675

[14] Bryan Wang, Meng Yu Yang, and Tovi Grossman. 2021. Soloist: Generating Mixed-Initiative Tutorials from Existing Guitar Instructional Videos Through Audio Processing. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–14. https://doi.org/10.1145/3411764.3445162

[15] Ha young Yang. 2023. A Cappella Arrangement and Teaching Strategy for Middle School Students. In *Conference Contents*. 218.