# VRChoir: Exploring Remote Choir Rehearsals via Virtual Reality

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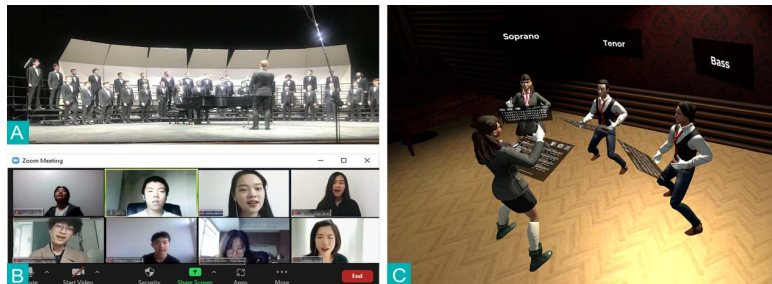Science
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Figure 1: In this work, we present a new approach to remote Choir singing. A) A typical in-person choral singing session with singers and the conductor. B) Singers and conductors are performing a remote singing session via a 2D teleconferencing system. C) Singers and conductors doing a "remote" singing session using our VRChoir prototype approach.

## ABSTRACT

Choral singing is a creative process that involves continuous, organized, nonverbal communication between conductors and singers. Since the COVID pandemic, choirs are moved to videoconferencing systems for rehearsals. However, the limitation of 2D video interfaces restricts the nonverbal communication, spatial awareness, and sense of presence in choral rehearsal. We designed, implemented, and evaluated VRChoir, a VR-based platform for choir rehearsals to improve these pain points. We evaluated VRChoir with conductors and singers with experience rehearsing in a remote environment. Our findings reveal that VR can be a starting point for improving the sense of presence and quality of non-verbal communication in remote music rehearsals.

**Index Terms:** Human-centered computing—Computer supported cooperative work; Mixed / augmented reality

## 1 INTRODUCTION

Since early 2020, the COVID pandemic has brought a devastating blow to choral rehearsal and performances (figure 1A) due to frequent lockdowns and social distancing. Choral singers have been shifting to remote methods (figure 1B) to continue the collaborative creative process. However, the lack of social connection, spatial awareness, and high-quality communication in a remote environment hinder the experience of choral singers in collaborating well in their creative processes. Previous work has addressed remote rehearsals using both synchronous (e.g., Zoom) and asynchronous approaches (mixing pre-recorded audios) by choir musicians [2].

Dedicated music jamming software, such as *Jamulus*[1], have been adopted to overcome issues of audio synchronicity by greatly reducing audio latency. These software approaches have been combined with Zoom to provide audio synchronization between singers and conductors during rehearsals. However, 2D feedback alone may not fully convey the rich non-verbal communication needed for choir rehearsals. Communicating the conductors' gestures without information loss on a 2D screen is challenging. Further research confirms this issue, showing that teleconferencing tools and jamming software are not enough to provide a rich rehearsal experience compared to in-person music rehearsals [1], but VR can be a highly reasonable alternative to teleconferencing systems as a visual platform for a remote synchronous musical collaboration [4]. Schlagowski et al. [7] performed a study with musicians using Mixed Reality in conjunction with Jamulus, with Microsoft Kinect for full-body telepresence via point-clouds, and received positive feedback during early tests. Instead of a depth camera and point cloud representations, our approach employs full-body avatars and virtual 3D environments.

We explore how VR can improve the experience of singers and conductors using remote 3D representations of people in a VR-based environment and its impact on their presence and enjoyment in remote choir rehearsals. In particular, we aim to solve the following problem: Can VR environments and 3D representations of people facilitate the sense of presence, spatial awareness, and quality of nonverbal communication of both choir singers and conductors?

## 2 VRCHOIR

We present VRChoir, an application that combines a conductor and a group of singers for choir rehearsal sessions in a virtual concert hall or auditorium. Our approach uses full-body 3D avatars to provide user presence in the virtual environment, as shown in figure 1C. Every conductor and performer has a "music panel," The music panel includes the music score, title of the music, composer of the music, and a button that can toggle a secondary menu for music selection. The singer or conductor can swipe on the music interface to change the current page. The visual system is developed in Unity with assets from the Unity asset store. It uses Photon PUN for network connection and runs on the Oculus Quest 2. The controllers are mapped to the avatar's hands and used to generate the posture using inverse kinematics. The application connects to the photon server after the user chooses the avatar and enters the concert hall. Each VRChoir client connects to the same Photon server.

Prior studies on synchronous music performance [5,7] have used Jamulus for audio transmission and jamming. We continue using Jamulus as the audio transmission tool for our study. The evaluation

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[1]https://jamulus.io/

moderator hosts a Jamulus server, and each participant was asked to connect to the server using a computer and use headphones for audio connection to the computer. All participants were connected to the server from various locations, where most participants' locations are within 1km from the evaluation moderator except for C2 (22.11km) and S9 (500.95km). The median distance is 0.29km.

## 3  PRELIMINARY EVALUATION

We conducted a preliminary user evaluation to assess whether VR-Choir effectively improves the overall experience of remote choir singing. We recruited nine singers (we refer to them as S1-S9, five males, four females), two professional music conductors with expertise in choral conducting (C1 and C2, one male, one female with previous conducting experience of seven and eight years, respectively). We followed the ethics protocol proposed and approved by the ethics board of our institution. The nine singers reported having experience with online choir rehearsals. Eight of the nine singers reported having prior experience with in-person rehearsals. Six of the nine singers reported having previous experience doing remote asynchronous rehearsals. Four previous reported experiences in synchronous remote rehearsals with *Zoom* and *Jamulus*. Both C1 and C2 had over one year of experience doing asynchronous choral rehearsals on *Zoom* since the COVID pandemic. C2 has experience in doing synchronous rehearsal using both *Zoom* and *Jamulus*.

### 3.1  Procedure

For each experiment, we used a group of 2-3 singers and one conductor, with one exception with one singer and one conductor, totaling three groups. In this exception group, a evaluation moderator assumed the role of the extra singer. At the beginning of the experiment, the evaluation moderator instructed the participants how to use the user interface. After the tutorial session, the participants started the rehearsal session and rehearsed *Amazing Grace*. After one iteration of singing the whole song, the conductor verbally responds with feedback to address the issues presented during the singers' signings. Then, the singers and the conductor start another iteration of singing and conducting from the beginning of the song and hold the same feedback session again. The process repeats until the conductor reports that the singers can perform the entire song properly. We conducted survey and semi-structured interviews with singers and conductors after each session. The survey consisted of usability questions (including SEQ [6],) co-presence questions, questions related to attentional allocations and perceived info understanding [3].

### 3.2  Results

The result of the evaluation is shown in figure 2. Singers rated high scores for enjoyment (Q1.1), ability to focus on tasks (Q1.2), and single ease questions to assess difficulty in task completion (Q1.3). The conductors reported in Q1.2 that their ability to focus on tasks has lower scores (M = 3, IQR = 1) due to audio latency. The singers reported strong co-presence with the conductor (Q2.1) and other singers (Q2.2). S4 mentioned that the VR environment *"makes me able to see others more realistically. I like the feeling and atmosphere of the people around me."* C1 described that VRChoir *"really brought back the sense of togetherness compared to Zoom."* C2 rated low on Q2.2 due to the impact of internet latency. Both singers and conductors have reported that it is easy to pay attention to each other (M = 6 for Q3.1 of both surveys) and remain focused on each other (M = 6 for Q3.2 of both surveys). Singers also reported a higher level of understanding of the status of other participants in the environments and non-verbal communication than conductors' scores. C2 noted that the fidelity of gestures conveyed via VR controller is inadequate for formal choral performances and more advanced choral rehearsals, hence scores in Q4 are low. Future research should explore whether the fidelity of the information conveyed by the conductor can be improved using hand tracking instead of VR controllers. C2 also suggested that the *"avatar should show facial expression"* and mentioned that facial expression plays a vital role in conveying the message of the conductor in choral rehearsals.

## 4  CONCLUSION

In this work, we presented an approach to using Virtual Reality as the visual platform for choral rehearsals with the help of existing music jamming tools (in our case, Jamulus) for audio transmission. We conducted user studies with nine singers and two conductors to analyze their experiences and feedback on VRChoir. The findings of our studies suggest that VRChoir could effectively improve the sense of presence and non-verbal communication over traditional teleconferencing systems for singers in choral rehearsals. The study also shows that conductors suffer more impact from the audio latency and low fidelity of hand gestures in VR, and lack of facial expression reduced the effectiveness of conducting. Overall, we argue that VRChoir provides a starting point for more effective remote music rehearsals. Future work could investigate whether the effectiveness of our approach is scalable to larger study with more musicians, have a more direct comparison with Zoom, and address technological limitations to further improve the experience of the rehearsal.
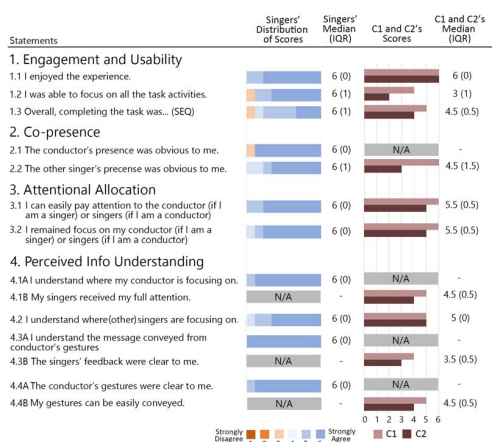


Figure 2: Results of the 6-point-scale survey from the singers and conductors, with median and inter-quartile range (IQR). Questions with the additional suffix "A" are exclusively answered by singers, whereas questions with the suffix "B" are exclusively answered by conductors.

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