

Exploring the Potential of Immersive Virtual Reality in Community Music Activities with Older Adults in CCRC

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Abstract

Designing immersive technologies for older adults often overlooks the situated nature of community-based activities. While Virtual Reality (VR) offers promising affordances for meaningful enrichment, its integration remains underexplored in community musicking. We conducted a two-month field study at a Chinese Continuing Care Retirement Community (CCRC), collaborating with 15 older adults and 3 music therapists through observations, interviews, and envisioning workshops. Our findings identify how older adults and therapists perceive VR through the lens of established musical values, including self-cultivation, social connectedness, and emotional and aesthetic resonance. We identified polarized responses to immersion shaped by personal history, and a recognized potential for VR to support musical imagination and reinterpretation beyond mere functionality. We discuss design considerations that emphasize therapists' roles as gatekeepers, the need for culturally meaningful content, and responsive interactions to support the inclusive and sustainable deployment of VR in managed care settings.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; *User studies*.

Keywords

Older Adults, Virtual Reality, Participatory Design, Community Musicking

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1 Introduction

Music engagement plays a significant role in the social and emotional well-being of older adults. As Christopher Small suggests, musicking is not merely performance but a fundamental social practice through which relationships are explored and established; it encompasses the active, relational process of making, sharing, and responding to music [83]. Community music activities thus serve as vital spaces for enrichment, self-expression, and connection among peers [18]. In aged care settings such as residential facilities, nursing homes, and continuing care retirement communities (CCRCs), these creative practices carry particular weight. As residents navigate progressive changes associated with aging, facilitated music activities serve not only as recreational resources tailored to their interests but also as non-pharmacological alternatives for psychosocial care [18]. Within these settings, these creative practices unfold amid a complex interplay of residents' diverse interests and care needs, organizational resources and infrastructure, and the relational dynamics of communal living [91, 97]. This complexity shapes the texture of musical participation itself—who participates, through what means, and how meaningfully they can engage [30].

Digital technologies have increasingly been introduced to support and extend these practices, serving as assistive tools, platforms, and interventional approaches that open new possibilities for more accessible, adaptive, and responsive musical engagement [20, 67, 72, 77]. Yet these approaches have predominantly served within therapeutic and clinical contexts, prioritizing functional accessibility over experiential richness in ways that risk reinforcing a deficit-driven narrative of old-age frailty [18]. As Cappelen and Anderson [13] caution, overemphasis on interface control may produce experiences that are "aesthetically limited," failing to deliver the nuanced pleasure of musicking. Researchers have increasingly highlighted the importance of non-functional factors (e.g., hedonics, aesthetics, creativity, and emotion) [16, 29, 33, 34, 76], pointing to an opportunity for emerging technologies to serve as expressive media for rich, flexible, and personally meaningful musical experiences, particularly within the facilitated, socially embedded contexts of community musicking in aged care settings.

Immersive Virtual Reality (VR) has emerged as a promising medium for such enrichment for older adults, with Head-Mounted Display (HMD)-based systems increasingly deployed in aged care

settings over the past decade [32, 89, 102]. Compared with low-immersive approaches (e.g., desktop or tablet-based 3D environments), semi-immersive systems (e.g., large displays and projection-mapping supported by body-tracking cameras), and fully immersive CAVE systems that require dedicated infrastructure and controlled environments, HMD-based VR has been shown to provide a compelling sense of presence and multisensory immersion while remaining portable, low-cost, and deployable within everyday care spaces [35, 36, 47, 88, 90, 91]. The sense of embodied presence enables a form of "virtual outreach"—bringing otherwise inaccessible environments, activities, and social experiences into the confined spaces of residential care [4, 35, 88]. Grounded in the "3I" framework of immersion, interactivity, and imagination [12], immersive VR serves as a potential medium for embodied musicking: its capacity to provide rich yet controllable sensory stimulation, accessible instruments, and spatial sound enables music to be experienced as a holistic, playful, aesthetic phenomenon rather than a mere task or activity.

While research on VR for aging has expanded into everyday enrichment contexts [80, 89], supporting virtual travel [49, 61], entertainment and relaxation [38, 85], and social connection [5–7, 105], the potential of immersive VR for supporting community musicking remains underexplored. Existing studies have positioned VR primarily as a restorative space for receptive listening within dementia care contexts, including soundscapes for sensory stimulation [15, 68], virtual concert environments drawing on biographical memory [32], and music-evoked emotional or reminiscence interventions [27, 35, 89]. How VR's affordances might be harnessed to support more active and creative forms of musicking for inclusive community practices has yet to be investigated.

Beyond this gap, introducing VR into sensitive care environments carries certain ethical risks, and sustaining its use beyond initial pilots and controlled settings remains a significant challenge [24, 37, 79]. Given VR's growing presence in aged care settings, and its nature as a sociotechnical system that both shapes and is shaped by the ecologies into which it is introduced [90], there is a pressing need to understand how it is perceived and valued by older adults and practitioners alike, from a situated, multi-stakeholder perspective. Without this grounding, we risk designing experiences that fail to align with existing community practices and values.

Rather than positioning VR as a technological solution to the limitations of traditional music activities or as a replacement for existing practices, this study explores how immersive VR might function as a situated complement that may support, enrich, or extend established practices, while also examining the conditions and boundaries of its integration.

In this paper, we report on a participatory field study conducted at a Chinese CCRC, a residential model that supports older adults across different stages of aging within an integrated living environment, which provided an ideal setting for examining how immersive technology might be introduced into an established, practitioner-facilitated music culture. We collaborated with 15 older adults (aged 75–92) and 3 music therapists who serve as the community's primary music activity facilitators through a three-phase process including field observations and interviews, hands-on VR experience sessions, and co-design workshops. Drawing on Suchman's theory of situated action [86], which posits that meaningful use emerges through

engagement with specific material and social circumstances rather than pre-determined plans, we engaged participants in a co-design process to investigate how VR might be situated within their existing musicking practices. Rather than evaluating a predefined technical solution against functional requirements, our approach privileges exploring technology's possibilities within the lived realities of community musicking. Specifically, our inquiry addresses three research questions:

- RQ1: What characterizes existing community musicking practices, and how is technology currently situated within these activities?
- RQ2: How do older adults and facilitators perceive the situated affordances of immersive VR for their music activities?
- RQ3: What design considerations are essential for integrating VR into community-based music activities?

Our study makes three contributions: (1) we provide a situated empirical account of community musicking, identifying how older adults' biographical values and cultural identities shape their musical participation alongside the practical realities and ethical responsibilities of facilitators; (2) we unpack how older adults and music therapists perceive the affordances of immersive VR through the lens of their existing musical values, including the polarized responses shaped by personal history and the conditions under which VR may feel meaningful or misaligned with participants' expectations and values; and (3) we articulate a set of design considerations informed by both older adults and practitioners for VR-mediated experiences that enrich community musicking while respecting its social, cultural, and relational fabric.

2 Related Work

2.1 Music Technology for Wellbeing in Later Life

Musical engagement supports multiple dimensions of healthy aging, evoking autobiographical memory, regulating emotions, and fostering social connection in community settings [14, 50, 58, 82]. Recognizing these benefits, HCI researchers have developed technologies spanning receptive and active musical participation [18]. Receptive systems enable older adults with varying degrees of cognitive impairment to access preferred music through adapted interfaces, such as "memory boxes" [20], tablet apps [94], or simplified switches [45]. Active technologies afford creative participation: tablet apps facilitate singing for novices [71]; MIDI systems and electronic instruments enable group music-making despite physical limitations [51, 67]; and motion-sensing or game-based platforms translate bodily movement into expressive sound, fostering agency and social participation [9, 23, 77]. Despite these efforts, existing music technologies have largely prioritized functional accessibility through simplified interfaces intended to accommodate age-related limitations in hearing, dexterity, or musical literacy [18, 23], with more innovative applications still largely targeting younger demographics and neglecting older adults' diverse needs and experiences. Emerging evidence suggests that older adults can meaningfully connect with music through technology in ways that extend beyond deficit compensation, encompassing reminiscence, creative expression, and social participation [46, 53]; yet how music technologies

might support inclusive, personally meaningful, and creatively differentiated musicking within community settings remains under-addressed.

2.2 Immersive VR for Social and Experiential Enrichment in Later Life

Research on immersive VR for older adults is undergoing a paradigm shift, transitioning from its clinical roots in rehabilitation toward broader applications in everyday enrichment and wellbeing [89, 98]. The advancement of consumer HMD-based VR systems has allowed immersive technologies to permeate daily life contexts across home, community, and care spaces [39, 55, 62, 65, 93]. Established commercial programs such as Rendrever and MYND ElderVerse have accelerated its adoption in aged care settings [57, 89]. Alongside this expansion, increasing attention has been paid to addressing the accessibility and safety challenges of deploying HMD-based VR in the field, including headset ergonomics, seated interaction design, and facilitation strategies [8, 79].

Immersive VR offers transformative potential through embodied presence and multisensory engagement, providing opportunities to fulfill aspirations often restricted by physical or geographical limitations, support emotional wellbeing through virtual travel and restorative immersion [48, 67], and foster social connectedness with older or new friends [5, 7, 81, 105]. Older adults have been found to experience meaningful levels of presence in HMD-based VR comparable to younger populations [66]. Passive, non-interactive experiences risk leaving older adults feeling like mere observers, while active exploration fosters greater agency, presence, and recognizability [35, 75]; simplistic environments may moreover fail to provide sufficient challenge and depth [1]. VR also holds potential as an expressive and creative medium, most meaningfully realized when integrated into a broader process involving art-making and sensory engagement rather than deployed in isolation [32, 68]. Together, these findings point to a need for more holistic approaches to VR design that emphasize experiential quality beyond functional and usability concerns, and that cater to the heterogeneity of older adults in ability, preference, and values rather than defaulting to assumptions of age-related decline [1, 29].

Yet the relationship between immersive VR and social engagement in community settings remains complex. VR has shown social value both through shared virtual environments connecting users via avatar representations [6, 26, 99] and through solo experiences that prompt conversation among co-located peers and care workers through casting systems [24]. At the same time, the physical occlusion of HMDs risks fragmenting co-located group dynamics, and many applications remain single-user experiences [21, 25, 70]. Integrating HMD-based VR into inherently collective community practices such as musicking activities calls for situated investigation in real-world care contexts.

2.3 Situated Design of VR in Aged Care Settings

Designing and deploying immersive VR in community care settings poses complex challenges, as older adults' engagement depends heavily on facilitation, social context, and institutional support [90]: while personalized VR can foster deep connections between older adults and care workers [97], its deployment often creates friction

with staff workloads and professional workflows [102, 103]. From an ethics of care perspective, VR facilitation in aged care requires practitioners to balance the enrichment potential of immersion against its inherent risks [98]. Practitioners therefore carry a duty to act as responsible gatekeepers, managing physical safety concerns such as falls, motion sickness, and disorientation upon headset removal, while attending to residents' needs and ongoing monitoring of their status [2, 92, 98]. Their role extends beyond risk management to a responsive, adaptive presence that mediates the experience in ways that respect resident autonomy and dignity [37], recognising that care practices in this context involve not only safety protocols but ongoing negotiations around personhood and relational quality [37, 97, 98].

VR experiences can prove bittersweet and vary considerably across individuals: rather than offering new and exciting opportunities, they may serve as a reminder of abilities or environments no longer accessible, leading to frustration or disengagement after initial novelty wears off [24, 35]. Transitions between virtual and physical reality therefore warrant careful design attention; practitioners have emphasized verbal and audiovisual cues to help residents reorient before removing the headset [31, 35]. These challenges underscore that VR cannot function as a standalone intervention; its sustainable use depends on trust building, thoughtful facilitation, gradual introduction, and designs that account for residents' wellbeing before, during, and after the VR experience. It is therefore vital to employ community-based participatory design approaches that include older adults and practitioners from an early stage, ensuring that VR is designed as an inclusive and supportive scaffolding for community practices [24, 59, 102].

3 Methods

We conducted a participatory field study at a Chinese urban CCRC over a two-month period for data collection. This was preceded by one month of preliminary engagement with CCRC managers and staff to build rapport, establish collaborative partnerships, and refine the project plan. Our approach was informed by participatory design scholarship that positions older adults as capable co-creators and experts of their own lived experience [52, 76, 78], emphasizes respectful long-term collaboration with aging communities, and cautions against technology-first framings that can reproduce ageist assumptions in design practice [7, 104]. The study unfolded across three phases: (1) field observations and semi-structured interviews; (2) hands-on VR experience sessions; and (3) co-design workshops (see Figure 1). Each phase involved both older adults and music therapists in various forms of participation. This phased structure was designed to transition from broad community understanding to focused scenario design, grounding technologies in existing musicking practices, eliciting informed perceptions of immersive VR, and collaboratively articulating considerations for integrating it into facilitated music activities.

3.1 Research Context

3.1.1 Study Site. We partnered with a CCRC in Beijing serving approximately 600 older adults, over 70% of whom are aged 80 and above. Nearly half of residents are independent in activities of daily living, while others require varying levels of support ranging



Figure 1: Study timeline

from mild assistance to full nursing care. The CCRC is designed as an open, mixed-use environment integrating residential living with medical, care, and recreational services to support older adults across different stages of aging. Upon learning of the community through public materials, the first author contacted the CCRC, disclosing our research intentions, study plan, and ethical approval. The managers and music therapists expressed interest and support for the project, offering practical guidance on research conduct, facilitating access to spaces and scheduling, and coordinating participant recruitment and introductions. Prior to formal data collection, the research team made several informal visits to gain an understanding of the available activities, spatial arrangements, and social dynamics, and conducted discussions with the community director and music therapists.

3.1.2 Types of Musicking Activities Offered. Musicking activities form a vibrant ecology of practice supporting older adults' holistic wellbeing at the CCRC. The community music program has been in place since 2021, led by licensed music therapists who facilitate two broad categories of activities. Music therapy sessions serve residents with a range of care needs, following structured therapeutic protocols to address goals such as cognitive stimulation, physical rehabilitation, emotional regulation, and sleep quality. Recreational music activities, including group singing, choir rehearsals, and recreational music sessions, are developed based on residents' interests and preferences, oriented toward social connection, creative expression, and continued learning. The CCRC features a dedicated music studio and open activity spaces equipped with pianos, guitars, percussion instruments, and large digital displays. To develop a comprehensive understanding of this ecosystem, we observed nine sessions spanning both categories, varying in theme, format, and participant composition (see Table 3).

3.2 Participants and Recruitment

Participant recruitment was coordinated with the community music program director. Recruitment criteria for older adult participants included: capable of basic independent living and verbal communication; free from severe sensory or cognitive impairments; and actively involved in community music programs. Music therapists

were included if they had at least six months of experience facilitating music activities with older residents at the CCRC. Participants were recruited through the music therapists, who identified eligible residents based on their knowledge of residents' physical conditions and comfort with technology. Researchers subsequently contacted interested residents directly, provided a full project briefing, and obtained informed consent prior to their participation. The study ultimately involved 15 older adults and 3 music therapists across different phases (see Table 1 and Table 2).

3.2.1 Older Adults. Older adult participants ranged in age from 75 to 92 ($M = 84.40$, $SD = 5.89$), comprising 11 female and 4 male participants. Five participants lived with their spouses in the CCRC. Participants had varied physical mobility, including two who used walking aids and one who used a wheelchair. No cognitive impairments were reported by therapists, and all were able to communicate independently and provide informed input throughout the study. Approximately half held a bachelor's degree, and all had completed at least middle school education. Participants demonstrated medium to high self-reported confidence in using digital devices such as smartphones and tablets (rated on a 1–5 scale), though no participant reported prior VR experience. All 15 older adults participated in Phase 1 and Phase 2; 12 continued into the co-design workshops in Phase 3, with two withdrawing due to scheduling conflicts and one due to discomfort caused by the VR headset.

3.2.2 Music Therapists. We collaborated with three music therapists responsible for facilitating the music program at the CCRC. All held relevant educational backgrounds and professional qualifications. Their experience at the CCRC ranged from six months to five years. All three had prior experience with VR: T1 and T2 had encountered it through professional contexts related to their music therapy practice, while T3 was an active consumer VR user with personal ownership of a headset.

3.2.3 Ethical Considerations. The study was approved by the Institutional Review Board (IRB) of the first author's institution. As all participants retained independent communication and decision-making capacities, informed consent was obtained directly from each participant prior to their involvement, and all were fully informed of their right to withdraw at any time. Before each research

ID	Gender	Age	Involved Music Activities	Tech Confidence
P1	F	85	Community choirs	Confident
P2	F	89	Community choirs, interest-based singing group	Confident
P3	M	90	Community choirs, interest-based singing group	Confident
P4	F	75	Community choir	Very confident
P5	M	81	Community choir	Unconfident
P6	F	83	Community choir, electric band	Neutral
P7	M	92	Community choir, electric band	Very confident
P8	F	92	Community choir, electric band	Neutral
P9	F	77	Community choirs	Very confident
P10	F	86	Music therapy group	Confident
P11	M	92	Music therapy group, interest-based singing group	Neutral
P12	F	81	Music therapy group, interest-based singing group	Confident
P13	F	75	Music therapy group, interest-based singing group	Very confident
P14	F	84	Community choirs, interest-based singing group	Neutral
P15	F	84	Community choirs	Neutral

Table 1: Older adults' demographic information

ID	Gender	Age	Years of Work Experience at this CCRC
T1	M	35	5
T2	M	26	2
T3	F	24	0.5

Table 2: Music therapists' demographic information

activity, the research team introduced its detailed purpose, content, and procedure to participants. To build trust and ensure ongoing informed participation, activity facilitators introduced the research team and our study purpose to residents at the outset of each phase, helping establish a foundation of transparency and openness. Throughout the study, we held regular debrief sessions with the project director to ensure participants' rights and privacy were well-protected and to address any communication or safety considerations, adopting flexible and context-sensitive measures across phases to mitigate potential ethical risks and safeguard participant wellbeing. During Phase 1 field observations, to minimize intrusiveness and protect privacy, data were recorded through field notes and sketches only, without the use of photography, audio, or video recording. During Phase 2 VR sessions and Phase 3 co-design workshops, therapists were present throughout to provide support and intervene if needed. All data were anonymized to protect participant privacy, and multimodal data collection in later phases, including audio and video recording, was conducted only with participants' explicit informed consent and used solely for research purposes.

3.3 Data Collection

3.3.1 Phase 1: Field Observations & Pre-VR interviews.

Field Observations. The music program director provided the research team with the activity schedule. At the outset of each session, the director introduced the research team to participants, clearly disclosing our identities and research purpose. We observed nine

45-minute sessions (4 music therapy, 5 recreational music activities), documenting activity content and procedure, space configuration, materials and technologies used, social dynamics, and facilitation strategies via structured field notes and sketches, without audio or visual recording to protect participant privacy. No more than two researchers attended each session, observing silently from the periphery of the activity space. These observations provided contextual grounding for understanding the ecology of community musicking and directly informed the design of subsequent interviews.

Semi-Structured Interviews with Therapists and Older Adults. Following the observations, we conducted one-on-one in-person interviews with 3 music therapists and 15 older adult participants. Music therapist interviews ($n = 3$, 60–90 minutes) investigated facilitated activity goals and practices, technology used in community musicking, and initial attitudes toward VR's potential and concerns. Older adult interviews ($n = 15$, 20–30 minutes) explored participants' musical biographies, motivations for attending and preferred modes of engagement in community music programs, and the perceived role of music activities in their daily lives.

For both groups, the final section of each interview included a brief structured presentation introducing immersive technologies, examples of VR use in aged care [91, 98], and VR-mediated music experience cases (e.g., reminiscence, meditation, performance, and collaborative social experiences) [15, 32]. This introduction was intended to establish a shared referential basis rather than to elicit evaluative judgments; participants' responses are reported in Section 4. Following this presentation, older adult participants were invited to describe imagined VR scenarios drawing on their musical biographies; this directly informed content selection for the VR experiences in Phase 2 (see Table 4 and Figure 10). All interviews were audio-recorded and transcribed.

ID	Session Name	Activity Type	Objectives	Participants	Participant Profile	Practitioners	Setting	Artifacts
A1	Sleep Relaxation Session	Music Therapy Session	Promote relaxation and improve sleep quality	11 (8F, 3M), aged 80–92	No reported CI; 1 wheelchair user; 5 using mobility aids	2 music therapists (T1, T2), 1 assistant	Community music classroom	Piano, TV
A2	Group Choir Music Therapy for Residents with Cognitive Impairment	Music Therapy Session	Improve attention span and provide visual stimulation	14 (10F, 4M); aged 81–94	Mild to moderate CI (clinically diagnosed); 7 wheelchair users	2 music therapists (T1, T2), 2 assistants, 2 interns, 4 care staff	Indoor semi-open space	Guitar, TV
A3	Community Choir A Rehearsal	Recreational Music Activity	Choir rehearsal and performance preparation	11 (6F, 5M), aged 85+	No reported CI; 2 mobility aid users	2 music therapists (choir director and accompanist)	Community music classroom	Piano, sheet music, smartphone (recording), TV
A4	Themed Music Therapy Session (Era-specific Repertoire)	Music Therapy Session	Promote lower-limb mobility exercise and social interaction	17 (9F, 8M); aged 82–96	Mild to moderate CI (clinically diagnosed); 6 wheelchair users; 3 mobility aid users	2 music therapists (T2, T3), 2 assistants, 7 specialized care staff	Indoor semi-open space	Guitar, TV, assorted percussion instruments (mostly handheld; some foot-mounted)
A5	Outdoor Sing-along Session	Recreational Music Activity	Encourage outdoor activity through low-barrier communal singing; repertoire spanning 1930s–1980s	50+; aged 70+	Mixed cognitive ability and mobility levels	1 music therapist (session moderator), community care staff	Outdoor open space	Guitar, audio system, handheld percussion instruments
A6	Reminiscence Music Therapy Session	Music Therapy Session	Reminiscence through classic songs; foster social interaction among existing and new group members	13 (10F, 3M); aged 70–90	No reported CI; 1 wheelchair user; 3 mobility aid users	1 music therapist (T2), 2 assistants	Indoor communal space	Guitar, audio system, percussion instruments
A7	Outdoor Sing-along Session for Residents with CI	Recreational Music Activity	Foster positive emotions and encourage outdoor activity through communal singing and listening	30+; aged 80+	Mixed mobility levels; predominantly nursing ward residents	1 music therapist (session moderator), care staff accompanying residents	Outdoor garden	Guitar, audio system, handheld percussion instruments
A8	Community Choir B Practice	Recreational Music Activity	Choir rehearsal of classical repertoire	28 (25F, 3M); aged 70–93	No reported CI; independently living older adults	1 music therapist (choir director and accompanist), 2 assistants	Community music classroom	Piano, guitar, audio system
A9	Music Therapy Session for Residents with CI	Music Therapy Session	Improve attention span and provide visual stimulation	15 (9F, 6M); aged 81–94	Mild to moderate CI (clinically diagnosed); 5 wheelchair users	2 music therapists (T2, T3), 1 assistant, 4 care staff	Indoor semi-open space	Guitar, TV, percussion instruments

Table 3: Observed community music activity sessions, comprising music therapy sessions and recreational music activities ($n = 9$). CI = cognitive impairment.

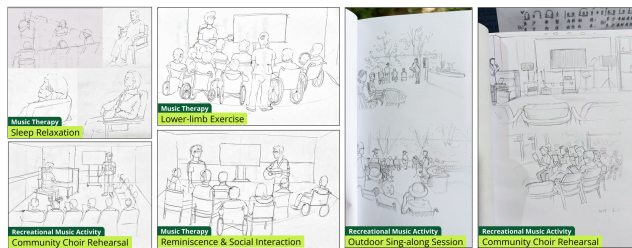


Figure 2: Field observation sketches depicting six observed music activity sessions, including music therapy sessions (A1, A4, A6) and recreational music activities (A3, A5, A8); see Table 3 for full session details.

3.3.2 Phase 2: VR First Experience Sessions & Post-VR Interviews. To support informed engagement with the technology, we conducted VR First Experience sessions with all 15 older adult participants, following prior work demonstrating that hands-on VR exposure is necessary for participants to form grounded views [7]. Drawing on Phase 1 findings, we prepared three categories of VR demo materials tailored to participants' expressed preferences and musical biographies (see Figure 10), delivered via a standalone Meta Quest 3 headset: (1) 360-degree music performance experiences (e.g., symphony orchestra, Peking opera); (2) travel and nature experiences with soundscapes (e.g., guided meditation, nature immersion); and (3) interactive music experiences (e.g., Maestro VR, Drums Rock).

All demo materials were previewed and evaluated by music therapists prior to use to ensure content appropriateness and safety.

Following the program director's recommendation and considering existing social relationships among participants, sessions were organized into four small groups of 3–4 participants (see Figure 3). Each session began with an introduction to the hardware and session procedure. Participants then individually selected 2–3 experiences from the three categories and took turns using the headset in a seated position, while others observed via a shared casting display or chose to step away. Each participant's VR experience lasted approximately 10–15 minutes. Music therapists were present throughout each session. Following the VR experience, each participant took part in a one-on-one semi-structured interview exploring their overall impressions (e.g., comfort, sense of presence and enjoyment), and how they envisioned using VR in relation to their musical lives. All sessions were audio and video recorded.



Figure 3: "VR First Experience" session photos and apparatus

3.3.3 Phase 3: Co-Creating VR Experiences through Participatory Design Workshops. The third phase translated insights from Phases

1 and 2 into three VR scenario concepts through a series of co-design workshops (see Section 4.3), engaging participants in commenting, refining, and extending proposed design concepts in relation to their own musicking values and practices. We conducted three participatory design workshops with 12 older adults and one online workshop with 3 music therapists, eliciting detailed feedback on the proposed scenarios, design preferences and suggestions, and practitioner perspectives on facilitation and integration. The workshop outcomes informed our iterative refinement of the concepts and generated considerations for the inclusive design of VR-mediated community music activities.

Workshop with Older Adults. Of the 12 older adults who continued into this phase, we divided them into three groups of four to ensure manageable group dynamics and sufficient discussion time. Each workshop was facilitated by one lead researcher and supported by three research assistants, and was held in a communal meeting room within the CCRC, lasting approximately 60–80 minutes (see Figure 4). Drawing on preferences and scenarios identified in earlier phases, the research team developed three VR design concepts. Storyboards in early-stage participatory design have been shown to effectively support older adults' creative thinking and envisioning when engaging with abstract or future technologies [3, 7, 69]; accordingly, each concept was represented as an eight-panel illustrated storyboard with an accompanying narrated script (see Table 5 and Figure 6). Storyboard images were generated with the assistance of AI tools (Google Gemini and Microsoft Copilot) based on detailed textual descriptions, interaction scripts, and sketches authored by the research team, and subsequently reviewed and refined by the authors to accurately represent the intended concepts. These large-format printed storyboards served as design provocations to stimulate critique and discussion. Audio and video recordings were collected throughout all sessions.

Each workshop followed a structured yet flexible format. The moderator opened with a brief introduction outlining the session goals and procedure, emphasizing the exploratory nature of the research and that there were no right or wrong responses. Participants were encouraged to speak freely, draw on their imagination, and go beyond both their prior VR experiences and the materials presented. This was followed by a brief warm-up activity revisiting themes from earlier phases and inviting participants to share reflections on their previous VR experiences.

The research team then introduced the three VR scenario concepts (see Table 5), giving participants sufficient time to read and annotate the storyboards independently. During this time, the moderator and research assistants helped to answer questions raised by participants about the depicted interactions and scenarios (e.g., how controllers work, how to play with other people, or how scene transitions function). For each scenario, participants were invited to share their feelings and thoughts freely, including what they liked or disliked, what the concept evoked for them, and how and with whom they could envision engaging with it in daily life. Participants were encouraged to propose modifications or new ideas, including changes to musical content, visual elements, features, and potential social activities. Research assistants documented verbal feedback and notable nonverbal reactions throughout.

After reviewing all three scenarios, participants were asked to rank the concepts by personal preference and explain their reasoning. The session concluded with an open-ended discussion inviting any additional ideas, reflections, or concerns.

Workshop with Music Therapists. We held a dedicated online workshop with the three music therapists via Tencent Meeting (around 80 minutes). As therapists had been present across both earlier phases, the session opened with the research team summarizing key findings from the field observations, interviews, and older adult co-design workshops, providing shared context for the evaluation. Therapists were then invited to share their overall reflections as participants who had observed the study unfold. The session then followed a similar structure to the older adult workshops, with therapists reviewing and discussing each of the three VR scenario concepts. To reflect the iterative design process, therapists were presented with both the original storyboards (versions A, as shown to older adults) and revised versions (versions B, updated based on older adults' feedback), with the rationale for each change explained by the research team; full storyboard versions are provided in Appendix A.1. Rather than focusing on personal experience, therapists' discussion centered on activity organization and implementation, potential for serving therapeutic goals, their own facilitation role, and considerations for community deployment. Research assistants documented therapists' responses and annotations using Figma's interactive commenting feature on a shared digital board (see Figure 5).



Figure 4: Co-creation workshop with older adults



Figure 5: Therapist workshop interactive boards with comments on three proposed scenarios

3.4 Data Analysis

Our data corpus included field notes and sketches, audio and video recordings of interviews and workshops, and participant-created artifacts such as annotated storyboards. All verbal data were transcribed verbatim. We conducted qualitative analysis following Braun and Clarke's thematic analysis approach [10, 11], beginning with open coding in which three authors independently reviewed the data and grouped codes into initial categories relevant to the research questions. Regular team debriefs were held to resolve discrepancies and produce a preliminary code set covering recurring topics

such as current musicking practices, motivations for participation, technology use, and attitudes and expectations toward immersive technologies from both older adult and music therapist perspectives. The team then iteratively compared codes across sources, reconciled interpretations, merged overlapping codes, and developed candidate themes, which were repeatedly checked against representative excerpts. Preliminary themes were also shared with music therapists to assess whether our interpretations aligned with their professional experience. The resulting thematic findings capture how older adults and therapists perceived the values and dynamics of existing community musicking practices, how VR experiences supported or challenged community musicking from their perspectives, and what conditions and design directions emerged for integrating VR into facilitated community music activities. All analysis was conducted in Chinese, with team discussions carried out bilingually; representative participant quotes presented in the findings are translations into English.

3.5 Positionality and Reflexivity

The research team comprises researchers with backgrounds in HCI, design, and gerontechnology, with experience in immersive technology development, participatory design with older adults, and interdisciplinary collaboration. We acknowledge that we may have initially held optimistic assumptions about VR's potential, shaped by prior experience with immersive technologies predominantly in controlled laboratory settings rather than real-world care environments. To mitigate potential biases, we approached VR as a provisional design material rather than a predetermined solution, and spent significant time building rapport within the community prior to data collection, positioning ourselves as learners rather than experts. We maintained reflexive discussion notes throughout the study and held regular debriefs with music therapists, sharing preliminary findings and soliciting their perspectives to keep our interpretations critically grounded. Our role evolved across the study, shifting from passive observers during fieldwork to active facilitators in the workshops. We remained conscious of the power dynamics inherent in care settings, explicitly positioning therapists and older adults as experts of their practice and lived experience to encourage open and critical feedback.

4 Findings

4.1 Phase 1: Overview of Current Practices and Initial Perceptions of VR

4.1.1 Overview of Observed Community Musicking Activities.

Music Therapy Interventions. Music therapy interventions followed structured, thematic sessions adhering to professional standards and protocols [19]. Resource constraints within the CCRC drive a preference for group-based interventions (typically 8–16 participants) over one-on-one sessions, consistent with observations of community-based music therapy in China [87]. All four observed therapy groups followed weekly 45-minute sessions across 8–12 week cycles with relatively stable membership. Therapists conducted comprehensive assessments before and during each cycle, developing intervention plans accordingly. Sessions followed a consistent structure (greeting, warm-up, music-based activities

and discussion, and closure), employing carefully prepared materials spanning tangible and digital formats, such as instruments, props, visual aids, and audiovisual media, to provide multisensory stimulation.

Beyond standard therapy phases, therapists' community-based practice emphasized situated flexibility to serve long-term relationship goals. T1 explicitly advocated for integrating therapy into older adults' daily living experiences to avoid an overly medicalized atmosphere, focusing on "holistic quality of life" rather than singular rehabilitation functions. This ethos was vividly illustrated in co-created group rituals. Therapists collaborated with Group A1 to adapt a cheerful 1980s friendship anthem into their unique "Hello Song" and "Goodbye Song." We observed A1 members using this greeting ritual even outside therapy sessions. Furthermore, relationships extended beyond sessions: therapists actively communicated with older adults and caregivers, observing their participation in other activities to build continuous understanding, capturing their interests and needs to dynamically integrate these into intervention plans and designs.

Recreational Music Activities. Recreational music activities operated with greater flexibility regarding venue, schedule, and composition. These activities aimed to provide social-emotional connection, creative expression, and opportunities for self-presentation. A key consideration was encouraging and respecting older adults' agency. Repertoire selection primarily respected older adults' interests while adapting to holidays, social topics, and popular trends. Despite structural variations, sessions followed similar patterns: staff welcomed participants, guided activities according to agenda, and reminded participants of upcoming sessions. In older adult self-organized interest groups, staff shifted from organizers to supporters, providing musical guidance, accompaniment, and logistical assistance.

Participation and Engagement. Observed participation varied considerably: from quiet listening and subtle body movement (hand-tapping, head-nodding) to instrument playing and singing along. Regardless of activity format, these sessions consistently created social spaces catalyzed by music. Older adults discussed song content and melodies, engaged in relaxed conversation, showed concern for each other's performance, and coordinated through percussion instruments. Interactions were most active among familiar peers and with familiar staff. Notably, social engagement often extended beyond the session's formal end, with participants lingering to sustain conversations sparked by the activity. To maximize accessibility, staff employed basic technologies such as microphones, television screens, and large-print lyrics. Nevertheless, these standardized supports could not fully bridge the participation gaps caused by older adults' diverse physical and cognitive conditions. Consequently, inclusion relied heavily on the therapists' ability to creatively and situatedly adapt tools and strategies to the immediate context.

4.1.2 Technology Integration in Community Musicking Practice. Technology was deeply embedded within the daily practice of community musicking, serving to enrich diverse, connected, and creative musical experiences.

Everyday Technologies and Infrastructure. Common digital devices served as essential infrastructure, including sound systems,

microphones, televisions, and computers. The community was also equipped with compact karaoke systems to encourage older adults' self-initiated practice and activities.

In the community choir, therapists primarily used group chats to distribute backing tracks, share recorded session videos, and communicate activity information. These platforms also fostered interest-based social connection, where members shared favorite online songs, exchanged performance videos, and expressed opinions. Participating in these technology-mediated interactions also developed digital skills as a natural byproduct. This growing digital confidence empowered older adults to experiment with new forms of musicking, extending their practice into online spaces. P2 described how her subgroup appropriated the mobile app "Quanmin K-song" to record and archive their singing over backing tracks: *"Seven or eight of us choose melodies we like, gather to sing, and record them... we now have 38 works preserved there,"* which they then shared with the choir group and family.

Pilots with Emerging Technologies. Beyond these everyday technologies, therapists reported piloting emerging tools and applications, including VR, AI, and GarageBand, and elaborated on the associated practices and challenges.

- **VR as Cognitive Training Tool:** T1 described a short-term pilot using VR and AI-generated voice for "image-guided lyric recall" conducted with 10 older adults with mild cognitive impairment. T1 noted that participants experienced varying individual challenges regarding comprehension, attention span, and visual perception. Critically, T1 reflected: *"It is difficult to simply replicate the process [in VR]. It doesn't quite have the sensitivity to detect and respond to older adults' feelings the way we do,"* which underscores the challenge and risks of deploying such systems as standalone substitutes.
- **Generative Tool Suno AI:** T2 explored using the generative tool Suno AI for collaborative songwriting. While older adults acknowledged the system's capability, they felt the results were "formulaic", "lacking a human touch", failing to accurately capture their creative intent or feelings. T2 emphasized that this experience highlighted the importance of empathy and emotional investment for interpretation.
- **GarageBand:** T1 and T2 organized a six-month "electronic band" project (n=7) using GarageBand on tablets, to create playful sound design with instrument enthusiasts in the community. Initially, older adults appreciated the novelty and learning aspect. However, sustaining engagement proved challenging due to the abstract interfaces and a strong preference for tangible instruments. P7 said: *"While I liked the novelty of the electronics... I feel we still need actual instruments to really stir up feelings. Just tapping on a tablet, it doesn't feel like the real thing. But playing a guitar or Huqin, it makes you feel like you are truly there, deeply invested in the moment."*

While therapists were generally receptive to new technologies and keen to co-explore with older adults, they maintained a cautious and critical attitude toward introducing them into daily practice, particularly in therapeutic settings. The primary challenges involved unfamiliarity, comprehension difficulties, and trust issues

associated with new technologies, as well as the risk of disrupting stable group dynamics. Before introducing new technologies, therapists rigorously assessed their feasibility, alignment with activity goals, and suitability for the specific needs and abilities of the participant group, recognising that adequate time for introduction and adaptation was essential for older adults to build familiarity and comfort. T2 emphasized that rather than promoting technology-based activities for their own sake, applications needed to align with older adults' needs and harmoniously integrate into existing practices and relationships, rather than weakening or displacing them.

Music Therapists' Perspectives on Potentials and Precautions of VR. Therapists identified immersion and multi-sensory stimulation as the primary technological affordances of VR, noting its capacity to improve attention span and provide rich synesthetic stimuli. T3 highlighted that the physical occlusion of the headset provided a unique sense of privacy and security; this "masking" effect allowed reticent older adults to feel less self-conscious about others' gaze, encouraging more authentic self-expression. T1 also proposed a concept of "collaborative memory bank", where VR served as a shared social medium for co-creating personalized narratives. By integrating family photos and life stories into virtual environments (e.g., reconstructing a childhood radio), VR acted as a therapeutic "visual memoir" for archiving and interaction [92]. This shared experience would allow older adults to discuss their observations within a collective virtual space, fostering meaningful dialogue and social connectedness.

Beyond the opportunities, therapists also raised important precautions. Excessive sensory stimulation, they cautioned, risks overwhelming older adults' attentional resources, triggering discomfort or distress, and diminishing their intrinsic motivation for imagination and engagement. Similarly, overly realistic virtual experiences may blur the boundary between virtual and real, potentially causing confusion or emotional disturbance for some residents. These concerns suggest VR should serve as a supportive scaffold rather than a standalone substitute. They further emphasized that design representations and interaction affordances should be grounded in real-world familiarity: because older adults often seek to understand the causality of interactions, abstract symbolism should be avoided in favor of realistic and intuitive mappings that support trust and comprehensibility.

4.1.3 Pre-VR Perspectives from Older Adults: Musical Values and Imagined Scenarios.

Perceived Values of Community Musicking. Drawing on pre-VR interviews, we explored how participants understood and valued their existing musicking practices. Their accounts reflected values consistent with prior research on creativity in aged care settings [97]: 1) self-cultivation through continued interest development, expanded sense of self-recognition, and opportunities for creative contribution (P1, P2, P3, P5, P6, P7, P9, P15); 2) emotional and aesthetic experiences inherent to music itself, as P9 described how activities evoked positive emotions that *"add joy and color to my life journey"* (P2, P3, P4, P5, P7, P9, P11, P14); and 3) social connectedness, where a sense of belonging extended beyond musical sessions themselves (P1, P2, P5, P6, P9, P13, P14). However, our participants articulated

these values in ways deeply shaped by their biographical histories and cultural specificity, revealing dimensions that extend beyond established accounts.

An outlet for self-expression. Music served as a medium through which participants articulated and performed deeply personal identities. As P1 put it, “*when words are insufficient, we express feelings and emotions through song.*” This was most vividly illustrated by P3, whose personal history of studying in the Soviet Union shaped his enduring relationship with Russian-era repertoire. He described performing each song first in Russian, then repeating it in Chinese—a practice not merely nostalgic but constitutive of self: participating in music, he reflected, had “*changed my personality.*” T1 observed that this impulse was broadly shared: “*everyone has a desire to express themselves—it is just suppressed in some people, and music can help to release it.*” For these participants, musicking was not a leisure activity but an ongoing act of biographical narration, evoking nostalgia and reminiscence through personally and culturally meaningful repertoire.

Harmony as aesthetic and social resonance. Participants held an orientation toward music that was simultaneously sonic, relational, and philosophically grounded. P9 articulated this with precision: “*what I enjoy most is the process of making voices harmonize during choir rehearsal.*” This was not merely a preference for pleasant sound, but an investment in a practice of collective attunement. Participants situated this aesthetic within a broader cultural framework, with P1 describing the progression of group singing as moving from “*singing together to resonating and empathizing together,*” invoking the classical ideal that the joy of music shared surpasses the joy of music alone. Harmony, in this sense, described not only choral blend but a mode of being-with-others and with the world.

Music as holistic wellbeing practice. Participants took musical participation as physiologically and psychologically integrative, and emphasized tangible wellbeing outcomes (P3, P4, P7). P3 described participation as an active approach to healthy aging, noting “*regulated blood pressure and preventing dementia.*” As P6 summarized, “*music has great power over us—it moves us physiologically and psychologically.*” This framing positions musicking not as therapy administered to passive recipients, but as a living practice through which older adults actively maintain their vitality.

Participants’ Imagined VR Scenarios for Musicking. Following the introduction of VR concepts and examples of VR-based musical experiences, participants were invited to imagine scenarios they would wish to experience. Their proposals reflected the musical values identified above, converging around three categories (Table 4): Participatory Musical Activities, Immersive Listening in Evocative Environments, and Nature-Immersed Soundscapes. Together, these categories span a broad spectrum of musicking—from active music-making and collaborative performance to receptive, contemplative listening—blending both participatory and passive modes of engagement. These imaginings directly informed the selection of VR content used in the subsequent First Experience sessions, grounding participants’ initial exposure in their own expressed preferences and values.

4.2 Phase 2: Older Adults Envisioning VR for Community Musical Engagement

Building on the imagined scenarios in Table 4, each participant experienced two to three VR applications tailored to their expressed preferences during VR First Experience sessions (see Appendix A.2 for the full list of applications used). Participants approached VR with discerning attitudes, recognizing its potential while remaining critical, and consistently evaluating what they experienced through the lens of what they valued in community musicking. The following themes illuminate how participants perceived the possibilities and limitations of immersive VR.

4.2.1 Feeling Enchanted and Feeling Detached. Virtual environments evoked strikingly polarized responses among participants. Personal history and lived experience fundamentally shaped whether participants formed emotional connections with virtual places.

Several participants experienced profound presence and enchantment within these environments. P14, who had previously traveled to Venice with her daughter, became completely absorbed in a virtual gondola ride: “*I was sitting in the boat... I even wanted to reach out and touch the moss-covered walls; the gondola song was almost identical to what I heard back then.*”

Beyond personal histories rooted in the past, participants’ current lived contexts also generated unique motivations for immersive engagement. P1 appreciated the aesthetic experience of a 3D virtual courtyard and expressed her desire for emotional dwelling within it, she exclaimed: “*That beautiful little courtyard... Could this belong to me? I want to make this my patch of land; it makes me feel peaceful and at ease.*” She further elaborated on how this virtual belonging countered her physical reality: “*Our living environment here is quite monotonous... [and physical travel] feels exhausting. But if you could insert such a novel, naturally beautiful environment into my confined daily space... my body and mind could receive renewal.*” For her, the virtual space offered inner tranquility and spatial possibilities that were particularly meaningful given the confinement of aged care living.

However, some participants remained detached when comparing virtual simulations to the richness of their memories. P11, who had traveled widely, found generic natural scenes disappointing: “*The beaches and waterfalls are unimpressive—I’ve had more beautiful experiences in my life.*” Citing his visit to Croatia’s Sea Organ, where waves create music, he anticipated that VR should offer thrilling, magical moments rather than mundane replications of reality. Similarly, P9 found a VR Danube scene lacking compared to her actual visit. She argued that authentic creation requires lived experience: “*You should go experience it yourself, then create based on your imagination... If you’ve truly been there, your feeling will be different.*” She noted that a scene would resonate more deeply if it captured specific atmospheric qualities, like a “golden hour” sunset, rather than generic moments.

Personal history thus served as both a resource and a lens, fundamentally shaping how participants interpreted virtual environments. True enchantment required not mere realism, but what participants described as “*a reality more perfect than reality itself*”—celebrating poetic moments that transcend ordinary experience through authentic, lived understanding.

Category	Description	Proposed VR Activities
Immersive Listening in Evocative Environments	Experiencing music or culturally meaningful sounds within spatially and temporally evocative contexts, where virtual environments enhance aesthetic, emotional, or nostalgic resonance	Solo and orchestral concerts in concert halls; Cathedral music (e.g., St. Petersburg Cathedral); Venetian gondola songs during canal tours; Peking Opera in traditional courtyards or theaters; Dance performances in plazas and tango ballrooms; Sonic reminiscence of old Beijing (pigeon whistles, vendor calls, blacksmith sounds); the Great Wall (patriotic songs)
Participatory Musical Activities	Active music-making where VR supports learning, practice, collaboration, and intimate musical companionship, enabling co-presence despite physical limitations	Group singing of classic songs; Ensemble instrumental performance; Karaoke; Instrument learning and practice (guitar, yangqin, drums); Virtual duets with family members
Nature-Immersed Soundscapes	Experiencing immersive natural or poetic soundscapes that create multisensory contexts for relaxation, contemplation, or aesthetic appreciation	Listening to the Rain Pavilion in traditional Chinese gardens (raindrops on large banana leaves); Forest wandering (birdsong, insect sounds, flowing streams); Mountain and coastal vistas (wave sounds, wind)

Table 4: VR scenarios for musical engagement proposed by participants

Beyond individual responses, we also observed how the VR experience shaped the social dynamics of the session itself. Bystanders (participants waiting for or watching others use the headset) were rarely passive. When a wearer became absorbed in a virtual gondola ride or a Moscow square, co-present peers often mirrored their gestures, swayed along, or called out comments, creating moments of spontaneous co-engagement. At the same time, bystanders expressed a desire to be more fully included: P2 and P3 asked how they could “join in,” and showed considerable interest in the casting screen, though they found it an insufficient substitute for shared immersion. These observations point to a tension between VR’s capacity to spark collective energy and its structural tendency to isolate the wearer, a tension that would surface more explicitly in the co-design workshops.

4.2.2 Supporting Musical Reinterpretation and Imagination Between Novelty and Familiarity. Participants recognized that the value of VR extended beyond its practical utility as a playback or learning tool, residing instead in its potential to support musical imagination and the reinterpretation of familiar practices. By transposing known musical activities into novel or previously inaccessible environments, VR enabled familiar practices and melodies to evoke fresh joy and new experiences.

This contextual reinterpretation was evident in how virtual environments expanded modes of musical participation and self-perception. For P3, who regularly sang Soviet-era songs, performing within a virtual Moscow square provided a catalyst for new ways of engaging with his repertoire. Beyond just singing, he began to learn the choreography of the virtual performers and incorporated these dance gestures into his own performance. This new mode of participation allowed him to feel as if he had “returned to his younger self,” suggesting that the virtual environment functions as a scaffolding for *contextual reinterpretation*, where familiar music is infused with new physical agency and a renewed sense of vitality.

Furthermore, VR offered a space for imagining performances that transcend physical boundaries. P7 and P8, a couple in their 90s, envisioned performing together within the Antelope Canyon—a location they cherished but could no longer physically visit. P7

imagined the scene: “*If my wife were playing the piano there while I sing along... that would be so romantic, it would certainly be wonderful.*” For them, VR was not a replacement for their existing practice, but a medium to amplify the emotional resonance of their partnership. By blending aesthetic exploration with familiar musical habits, VR provides an imaginative sandbox where older adults can pursue creative expressions that transcend the constraints of reality, offering renewed and exciting opportunities for musical engagement in late life.

Notably, when asked about their preferred social context for VR use, most participants emphasized wanting to share the experience with like-minded friends rather than in open group settings, suggesting that the social value of VR musicking may depend as much on the quality of companionship as on the technology itself.

4.2.3 Seeking Liveness and Responsive Dialogue for Active Participation. Beyond passive observation, participants sought “liveness” and responsive dialogue—environments that would react to their presence and enable active participation rather than fixed, static experiences. This perceived vitality served as a crucial catalyst for deep engagement and agency. For several participants, enchantment was sustained by dynamic soundscapes and signs of life; P1 and P10 identified the chirping of “flying birds” and the sound of “flowing water” as essential sensory anchors that transformed a static simulation into an active, living place.

This desire for liveness manifested as a longing for a multi-layered “dialogue” with the environment, spanning verbal, environmental, and embodied interaction. P14, for instance, criticized the “lifeless” quality of certain scenes, suggesting that the environment should “speak” or respond to her presence to enhance engagement. Such expectations often translated into a drive for embodied interaction. Observing virtual drummers, P7 expressed an instinctive urge to “*play along with them... essentially participating myself,*” while P2 similarly desired a sense of “*tactile sensation*” to grasp virtual objects. Enchantment was not merely a result of visual realism, but was driven by a responsive dialogue—where the environment reacts to their presence and triggers a renewed sense of agency and vitality.

4.3 Phase 3: Co-Designing VR Experiences through Scenarios as Provocations

The research team developed three VR scenarios as design provocations, grounded in the ecology of community musicking observed in Phase 1 and the perceptions of VR affordances that emerged during the Phase 2 VR First Experience sessions. The CCRC's existing musicking ecology encompasses a range of participation scales, from individual practice and therapist-guided sessions to open community group activities, and participants' own proposals similarly spanned individual, intimate, and collective forms of engagement. The scenarios reflect this diversity. The Memory Train (Scenario 1) drew on participants' strong autobiographical and nostalgic connections to era-specific repertoire, proposing an embodied reminiscence journey through music-triggered life stages. The Ensemble Band (Scenario 2) responded to participants' desire for liveness and active musical participation alongside their emphasis on social connectedness, exploring how VR might support collaborative performance and learning among peers. The Natural Sound Island (Scenario 3) built on participants' appreciation for emotional dwelling and aesthetic contemplation within immersive environments, centering on the shaping of a personal soundscape through embodied interaction. The variation in social participation modes across scenarios is therefore grounded in both the community's established practices and participants' expressed preferences.

These scenarios were presented as illustrated storyboards and narrated scripts (Table 5), and participants' responses should therefore be interpreted as design-oriented feedback on envisioned experiences.

4.3.1 Prioritizing "Presence" Over "Representation." In the co-creation of the "Memory Train" scenario, participants' feedback largely validated our initial design expectations regarding the use of embodied interaction to trigger reminiscence, while also uncovering deeper needs for personal identity and cognitive support. In the evaluation of storyboards, participants showed high consistency in their preferences, favoring "Panel 4: Voice Memories in Tuning" and "Panel 6: Childhood Toy Station." Participants generally agreed that triggering era-specific tracks (e.g., the 1950s folk song "Let Us Sway the Twin Oars") by rotating the radio knob was a key facilitator for memory activation, as these melodies had long been internalized as a collective cultural identity for this generation (P4, P9, P14). P9 mentioned that music permeated her entire experience in the Youth Palace Choir, while P14 further articulated the potential cognitive health benefits of such interactions: "I think this could get our elderly brains moving... the dialogue should adapt to this. For example, when an object appears, even a fragment of memory—'Hey, I seem to have seen this somewhere'—allows one to immediately recall places they've been. This is helpful for preventing dementia."

Furthermore, the interactive vintage objects provided in Panel 6 were recognized as effective cognitive scaffolding (P3, P10, P14). P10 noted that seeing these objects immediately evoked specific life episodes, such as "zhua guai" (playing jacks) and "zhuai bao" (sandbag tossing). Interestingly, for P12, VR served not only as a tool for looking back but also as a medium for wish fulfillment. She particularly favored the interaction of rolling a hoop, as it compensated for her childhood regret of being unable to participate

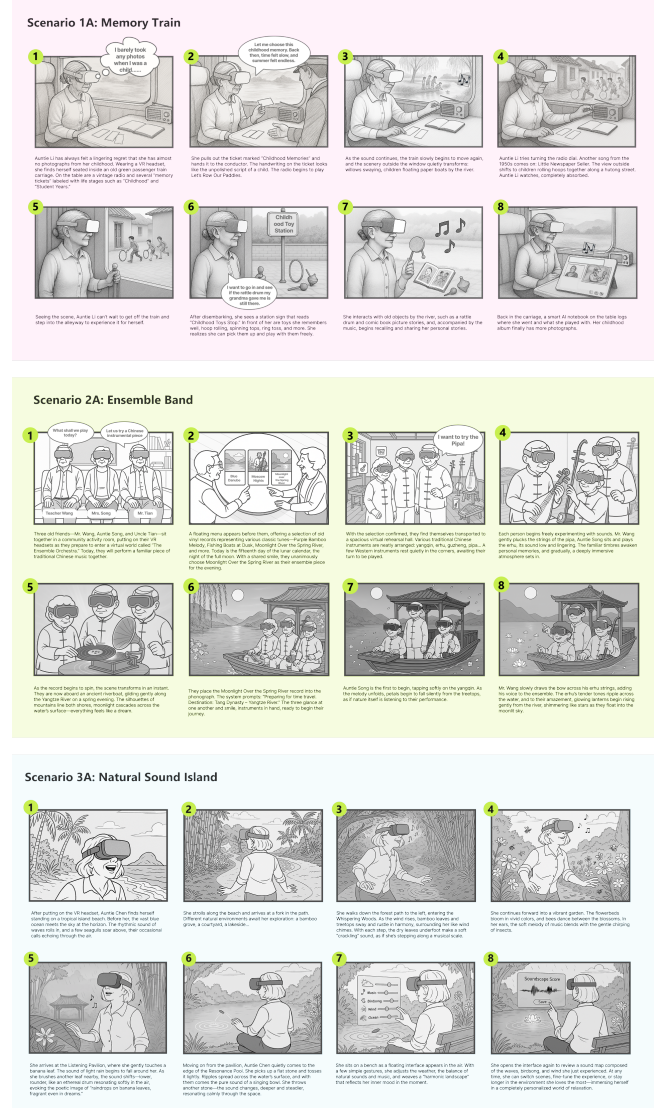


Figure 6: Storyboards for the three initial VR scenarios presented to older adult participants during co-creation workshops: Scenario 1A (Memory Train), Scenario 2A (Ensemble Band), and Scenario 3A (Natural Sound Island). Each storyboard consists of eight panels illustrating the user journey, interaction mechanisms, and key narrative moments.

due to physical limitations. This transition from "observer" to "active participant" underscores the value of immersive technology in maintaining older adults' sense of self-efficacy.

However, some participant feedback diverged from our initial design metaphors. Although we envisioned the train as a romantic vehicle for a life journey, P2 and P14 pointed out that train travel in their lived experience was often tedious and boring, frequently associated with the exhaustion of long-distance journeys. This suggests that a high-fidelity recreation of a specific environment

Scenario	Core concept and setting	Key interactions	Outputs and intended outcomes
Memory Train	An immersive music based reminiscence system situated in a vintage green train carriage. The carriage includes a retro radio and memory tickets labeled with life stages such as Childhood or Student Days.	Users select a memory ticket and hand it to a virtual conductor to trigger era specific music and window scenes. Users rotate a radio knob for non linear track and scene switching. Users tap the window to enter a 360 degree panoramic reminiscence space where they interact with vintage objects such as rattles and picture books.	The system uses AI to convert users narration and interaction records into a visual diary as a memento of the journey. The experience aims to scaffold reminiscence and support autobiographical narration.
Ensemble Band	A multi user collaborative music social system. The experience begins in a virtual rehearsal room equipped with Chinese and Western instruments such as erhu pipa and cello.	Multiple users meet and collectively select a piece at a central track console. The system transports the group to a themed virtual environment matching the music. During performance, users collaborate in rhythm with background music. The system provides intelligent assistance to maintain harmony and triggers environmental feedback such as fish leaping or lanterns rising.	The experience aims to enhance social connectivity through audio visual resonance and co performance, while reducing coordination burden through intelligent assistance.
Natural Sound Island	A sensory regulation system on a virtual island composed of beaches bamboo forests and gardens. The scenario centers on shaping a personal soundscape through embodied interaction.	While wandering the island, touching a banana leaf triggers light rain sounds and poetry recitation. Throwing stones into a pond induces singing bowl acoustic waves. A floating transparent control panel allows users to adjust the ratio of background music to natural sounds such as waves or birdsong, and to adjust environmental parameters such as sunlight intensity via sliders.	User preferences are saved as a visual natural harmony score. The experience supports autonomous emotional regulation and self healing through controllable soundscape composition.

Table 5: Co designed VR musicking scenarios and their interaction logic

may inadvertently anchor users to mundane or unpleasant physical sensations rather than the intended poetic reminiscence.

Our findings indicate that perfectly reconstructed historical environments can become triggers for traumatic memories or historical scars. For example, P11 recalled the traumatic experience of his home being ransacked, during which his cherished German and Russian violins were destroyed. Similarly, P12 and P13 expressed a strong emotional avoidance of the catastrophes of the 1950s, describing past memories as not very beautiful and concluding that for some, the effort to remember is simply too painful.

These instances suggest that in increasingly complex mixed-reality scenarios, simply pursuing extreme virtual immersion is insufficient. Instead, the system must achieve optimal presence, which involves maintaining a seamless, bi-directional transition between realities to preserve the user's physical integrity and awareness of the real world [28]. Within this balance, music and sound design should replace visual replication as the more central and safer triggering mechanism.

Compared to the potentially oppressive nature of visual immersion, music constructs a gentler space for imagination where melodies tied to specific historical backgrounds often prove more effective and inclusive than physical objects in triggering deep expressions of experience. For instance, P1 suggested incorporating preschool nursery rhymes like Shui Niu (Water Buffalo) to enrich historical depth without forcing a totalizing, high-pressure visual immersion that might trigger negative emotions; furthermore, through embodied actions and sonic interactions—such as blowing a virtual pigeon whistle—music guides users to evoke personalized and detailed autobiographical memories at their own pace, enabling older adults to engage more actively with their past, while the preference of P4 and P6 for specific hometown soundscapes like the springs of Jinan further proves that music provides rich contextual information while serving as a supportive rehabilitative tool that ensures psychological safety by avoiding overwhelming emotional impacts.

4.3.2 Enhancing Musical Agency and Intellectual Growth through Knowledge-oriented Interaction. In the co-creation of the Ensemble Band scenario, participants' feedback shifted from emotional resonance toward a demand for content depth, cultural authenticity, and proactive learning. While the initial design intended to support social musicking, the findings revealed a deeper knowledge-oriented musical agency among the older adults, who sought intellectual growth alongside social connection.

The integration of traditional Chinese instruments and classic repertoires was praised for its cultural relevance. P11 and P12 expressed a strong nostalgia for the Erhu, with P11 suggesting that including pieces like "The Moon Reflected on the Second Spring" would enhance the experience. P14 highlighted that the "browsing repertoire" feature provided a sense of autonomy, allowing participants to lead the collaboration by choosing familiar pieces for the group.

However, many participants were not satisfied with merely performing selection actions or observing performance results; they explicitly demanded supplemental musical background and instrument knowledge. For these participants, the meaningfulness of the interaction was directly tied to the "gain" of new information. P1 criticized the current interaction as being "too thin" and "monotonous", specifically targeting the lack of educational depth: *"I feel I haven't gained any progress... Why did I choose the cello? What is its timbre? If you could write a few lines about these, we would gain knowledge and broaden our horizons. The current content is far too limited."* P15 echoed this need, suggesting that the system must provide rigorous background on compositions and composers to make the experience meaningful. This demand for intellectual growth reflects a sophisticated understanding of musicking that encompasses not only listening and playing but also the interpretation and reflection of music. If an interaction chain only allows for choices without explaining why those choices matter or what musical significance they carry, the system may fail to support the users' expectations for self-improvement and identity continuity. Participants also envisioned VR as a space for reigniting past hobbies: P6, who had forgotten the Yangqin (dulcimer), saw the system as a platform to "start from scratch," while P1, P9, and P15 emphasized expanding the instrument library to include the Jinghu and Bianzhong (bronze bells) to ensure the authenticity of the ensemble experience. P14 further proposed adding interactive NPCs for musical dialogue to enhance the vibrancy of the social space.

These individual-oriented priorities are consistent with findings from Phase 1, where participants framed musicking primarily as a vehicle for self-cultivation and identity continuity. Yet participants also expressed genuine enthusiasm for the collaborative possibilities within the Ensemble Band. P2 envisioned a scene where participants could drum, sing, and enjoy scenery together, with different instruments complementing one another. She described the ideal outcome as an experience where *"everyone sings together in harmony, that would be the best,"* and further imagined the group performing along the Blue Danube with an orchestral backdrop. P3 similarly valued the joy of ensemble performance, describing it as *"the happiest thing, listening to each other and learning from one another, choosing different instruments that complement each other."* Within this collaborative context, P3 recalled a childhood memory of crafting a Jinghu from snake skin and performing on

stage, expressing a wish for VR to "recreate" that formative moment. His response illustrates how the harmonious social setting of the ensemble scenario facilitated a natural flow between collaborative engagement and personal reminiscence, enabling participants to revisit meaningful musical memories and articulate creative aspirations in ways that felt unintrusive. These responses suggest that the collaborative environment served as a generative backdrop supporting a richer, more harmonious experience, with its meaning rooted in the shared atmosphere and mutual recognition it cultivated. Prior work on social VR with older adults has similarly found that collaborative experiences are most valued when structured around facilitated, meaningful activities with clear social purpose [7]. We elaborate on this preference for socially porous over fully co-immersive experiences in Section 5.1.

4.3.3 The Gentle Appeal of Present-Centered Sensory Immersion and Serenity. Participants responded to the Natural Sound Island with particular warmth, describing it as the most "vibrant" and "immersive" concept (P1, P9). A quality that participants identified was the scenario's open-ended, non-task-oriented character. The Natural Sound Island invited participants to dwell at their own pace within an exploratory sensory environment. This quality appeared to resonate with a deeper aspiration toward serenity and harmony. P1 found the narrative script alone sufficient to evoke resonance, noting that it could "lead the audience into" the envisioned virtual world. She was particularly drawn to the prospect of inhabiting such a space as her own: *"This patch of land... I have always wished for a courtyard with flowers and water. It is quite captivating."* For P1, the scenario offered the possibility of inhabiting a contemplative space with flowers and water that she could call her own, extending her lived environment beyond its physical boundaries through sensory immersion.

Notably, although the scenario was not designed around reminiscence, participants' engagement with its sensory elements naturally evoked personal memories. P3 associated the depicted seascape with his youth in Dalian, while P14 recalled a trip to Venice, noting that the sounds of waves and seagulls acted as powerful anchors for reliving cherished experiences. These responses suggest that an immersive environment oriented toward present-moment serenity can serve as a gentle and unintrusive pathway to reminiscence, allowing memories to surface organically through sensory resonance rather than through directed prompts.

A further finding was participants' appreciation for sensory agency and multi-sensory integration. P12 and P2 praised Panel 8 for its envisioned ability to merge individual elements such as waves, birdsong, and wind into a customizable whole. P15 highlighted that the clarity and distinctiveness of each "musical image," such as the sound of rain, falling leaves, or the singing bowl, would allow users to consciously perceive and differentiate between various emotional qualities of sound. P6 described the envisioned transition from the rhythmic sounds of nature to the meditative resonance of the singing bowl as a complete journey of finding inner peace: *"From the sound of waves to the sound of the singing bowl... the whole process is a gift of music. It leads from the external sea to the inner quietness; it makes one feel truly still."*

However, participants also provided critical insights into the temporal continuity of such an experience. They noted that the

control panel depicted in Panel 7 presented cognitive challenges due to false affordances [60]. Although the design intended to provide autonomy and personalized adjustment, participants struggled to infer system feedback and functional purposes from the storyboard's limited physical cues, leading to cognitive load and unintended disruptions in the imagined flow of immersion. P9 argued that the interaction should unfold as a gradual, step-by-step process and cautioned that Panel 7 risked breaking the lingering emotional state that the scenario had carefully cultivated. P2 similarly questioned the linguistic framing of "controlling the weather," suggesting that "adjusting the atmosphere" would be a more natural and acceptable description. These observations underscore that for present-centered experiences, the preservation of an uninterrupted sense of harmony is paramount, and any interface element that introduces task-like cognitive demands risks undermining the very serenity that participants valued most.

4.3.4 Therapist-Led Intervention for Scaffolded Safety and Continuity. Based on the integration of elderly users' needs, therapists highlighted the necessity of a "third-party controller" within the interaction workflow. They proposed a collaborative control mechanism where therapists intervene from the backend—adjusting volume, timbre, and repertoire selection—to ensure that participants' emotional fluctuations remain within a safe range. To address safety requirements, therapists introduced the therapeutic concept of a "Safe Room," emphasizing that the interaction must support an "anytime-exit" policy and a safe, incremental withdrawal process rather than abrupt visual immersion or disconnection.

In this context, sound serves as a critical bridge balancing virtuality and reality. To mitigate the risk of participants failing to distinguish between virtual and real-world boundaries, therapists suggested using music as a safe transitional cue. For instance, introducing familiar radio broadcasts as auditory anchors during the entry phase, or utilizing melodic fade-outs as signals for safe withdrawal in the exit phase. This therapist-guided interaction model, which employs sound as a safety boundary for VR musicking activities, fosters deep emotional engagement while simultaneously safeguarding the psychological and physical integrity of older adults.

5 Discussion

5.1 Summary of Findings

Our study investigated immersive VR integration into community musicking within a CCRC, where activities are facilitated by music therapists and staff. Participants evaluated VR not merely as an "experience," but as a resource within an existing ecosystem of group routines and social relationships. We interpret these findings by confirming established claims on VR and healthy aging, while extending them through the lens of facilitated, multi-stakeholder practice.

Our results reinforce literature suggesting VR supports older adults' well-being when experiences are facilitated, purposeful, and personally meaningful [5, 32, 89, 98]. Participants found VR "emotionally engaging" when content resonated with personal preferences, such as aesthetic enjoyment or relaxation, and valued it most when it generated something talkable: a story to share, a

prompt for discussion, or a musical moment others could respond to.

While our findings confirm several established claims, they also reveal a different underlying logic for VR in care communities. VR has largely been treated as a standalone medium focused on optimizing the in-headset experience (e.g., presence, embodiment, and control), or as a tool designed around narrow intervention goals. Our participants, by contrast, evaluated VR through the practical and social realities of community musicking: activities are facilitated, time-bound, shaped by diverse levels of participation, and embedded in relationships among older adults, staff, and therapists [59, 68, 87, 98]. This shifts the central question from immersion quality toward how the experience functions within group practice. Below we highlight several ways our findings challenge and extend prior perspectives.

5.1.1 VR as Support for Musical Growth, Self-Cultivation, and Knowledge-Oriented Engagement. Many participants approached VR not as a medium for passive enjoyment but as a potential vehicle for musical growth, self-cultivation, and positive change. This orientation, consistent with research on music and lifelong development in later life [18, 30], was most visible in the workshop discussions around the Ensemble Band scenario, where feedback shifted from emotional resonance toward demands for cultural authenticity, knowledge depth, and intellectual engagement. Participants valued the cultural specificity of the scenario, recognising the potential of embodied engagement with traditional Chinese instruments and classic repertoires as exciting opportunities for learning and creative exploration. Yet participants sought more than performance: they explicitly demanded contextual knowledge alongside musical interaction—information about instruments, composers, and musical history that could deepen their understanding and broaden their horizons. Their critiques of the lacking educational depth capture a broader pattern: for many participants, the meaningfulness of a VR-mediated musicking experience was tied to whether it supported ongoing learning and self-improvement, not only in-the-moment affect, positioning VR as a medium that can support older adults in pursuing musical identities and aspirations that remain unrealized in everyday community practice [18, 30]. Unlike conventional tools such as videos or consumer music apps, VR's integration of scene, sound, and embodied presence offers a more immediate pathway for knowledge-oriented engagement, particularly given the resource and time constraints that limit individualized musical support in community programs.

5.1.2 Scaffolding Reminiscence VR: Music and Sound as Pathways into Biographical Memory. Across interviews and workshops, participants consistently emphasized music and sound as particularly immediate and evocative pathways for autobiographical recall and expression [20, 22]. Era-specific songs, familiar timbres, and everyday sound cues were described as effective triggers into remembered contexts, often prompting rich and detailed storytelling [17, 93]. This extends the role of audio in reminiscence-oriented VR from a background element to a primary mechanism through which memories are accessed and communicated. Several participants noted that musical expression can convey experiences that are difficult to fully capture in everyday speech, suggesting that reminiscence-oriented VR should support not only remembering

but also expressing through sound-based interaction. This positions reminiscence VR as an expressive space where carefully curated and interactable audio (e.g., melody, lyrics, instrumentation, and responsive sound cues) can help participants externalize feelings and share personal narratives [15, 32]. To enable safe and sustainable use in community settings, such designs should also include facilitator-facing controls for pacing and intensity, as well as clear mechanisms for pausing, transitioning, and exiting content that evokes distressing or painful memories [87, 98]. Our findings also suggest that emotional relaxation and reminiscence need not be treated as separate design goals in VR musicking. While the Natural Sound Island scenario was designed primarily for sensory relaxation and emotional agency, several participants found that its ambient soundscapes incidentally evoked personal memories—P3 associated the virtual seascape with his youth in Dalian. This suggests that sensory-oriented VR experiences may open a less pressured pathway into reminiscence, one that does not require participants to directly confront historical content but allows memory to surface naturally through embodied immersion [27].

5.1.3 Extending “Who Is the User”: Beyond the Headset Wearer. In community musicking contexts, the notion of the “user” needs to expand beyond the headset wearer. Traditional user-centered design tends to focus on the individual who directly operates the system, yet in real-world community deployment, VR-mediated experiences unfold within a shared social space where friends, care staff, and passing residents are all present and affected [41]. Bystanders, non-wearers, and facilitators are not peripheral to the experience but constitute its social ecology. This is particularly important in community musicking, where meaning is co-produced through shared attention, mutual recognition, and social exchange.

Music offers a distinctive bridge here: unlike visual immersion, which remains occluded behind the HMD and requires additional infrastructure such as casting displays to be partially shared, sound is inherently permeable and can be heard and felt by everyone in the space. Participants suggested that sound, singing, and rhythm could allow bystanders to indirectly participate, singing along, responding to what the wearer is hearing, or using audio as a shared anchor for discussion. This points toward a model of distributed participation, where multiple roles (wearer, bystander, facilitator) can meaningfully contribute and communicate, extending social VR discourse beyond remote co-presence toward situated, co-located community practice. This can be instantiated through concentric participation layers [101]: the HMD wearer occupies the core interaction layer while remaining anchored to the physical environment around them; therapists or staff operate from a facilitation layer, using streamed displays and observational cues to guide pacing and provide timely support; and bystander residents engage through shared spatial audio or thoughtfully positioned displays, moving freely within the space while remaining connected to the experience [64]. These roles are not sequential but dynamically interwoven throughout the session.

The design question for VR in community musicking is therefore less about enabling simultaneous multi-user immersion and more about maintaining permeable boundaries between wearers and bystanders, where music and sound serve as the connective tissue between individual experience and collective participation. Not all

aged care facilities will have the resources to equip every participant with a headset; designing for bystanders as active users in their own right is therefore both a social imperative and a practical necessity, and calls for further work on cross-reality interaction models that support co-located mixed-presence engagement in care settings [28, 41].

5.2 Design Implications

Building on our findings, we outline design implications for VR systems that aim to enrich community musicking in real-world aged care settings. These implications treat VR as a facilitator-supported medium whose value depends on how well it fits existing community practices, social relationships, and older adults’ diverse motivations, rather than advocating a technology-first approach.

5.2.1 Prioritizing Musical Biography as Design Material and Facilitation Resource. Participants’ biographical histories proved to be the essential determinant of whether a VR experience felt resonant or alienating. Designing meaningful VR musicking therefore requires treating musical biography as primary design material rather than supplementary context, encompassing era-specific repertoire, formative memories, cultural associations, and unrealized aspirations that medical or diagnostic profiles rarely capture. Practically, brief biographical elicitations should precede VR sessions, not as formal assessments but as conversational exchanges that surface specific memories, preferences, and emotional boundaries, helping facilitators understand both what may resonate and what may risk triggering harm [91, 92]. Equally, post-VR conversation inviting participants to share what they experienced in relation to their own memories transforms individual immersion into shared meaning-making and extends the expressive value of the encounter [68, 89]. This positions VR not as a standalone technology encounter but as one moment within a broader relational and facilitated practice. Facilitators play a central role in enabling this: their presence, trust-building, and contextual knowledge transform a technology encounter into a meaningful and safe expressive space [68, 89]. Participation need not be limited to headset-based interaction; listening, commenting, and sharing memories are equally valid forms of engagement that well-designed sessions should accommodate [104].

5.2.2 Designing for Shareable Stories and Lasting Traces Beyond the VR Session. The value of a VR musicking experience need not end when the headset is removed. In community aged care settings, shared memory and ongoing conversation sustain social bonds and a sense of belonging. When VR experiences are designed not only for the moment of immersion but also for what comes after, they have the potential to generate stories, memories, and artifacts that continue to circulate within the group, extending the social value of musicking beyond the session itself.

Tangible traces of the virtual experience can serve as bridges between virtuality and everyday social life. Workshop discussions revealed that participants anticipated recounting their VR experiences to peers and family. P14 expressed a wish to take a photograph with the canals of Venice she had revisited within the virtual environment during Phase 2, to share with her daughter as a memento of their real trip together decades ago. Such artifacts function as tickets to talk [100], giving others a concrete anchor

around which to initiate conversation, share memories, and build connection. Designs should therefore support the generation of shareable touchpoints, whether physical or digital, such as a printed memory summary, a commemorative photograph, or a personalized soundscape recording, that give others something to respond to [37]. Advances in generative AI further open possibilities for creating personalized artifacts in real time or post-session, drawing on data collected during the VR experience to produce customized text, images, or audio that capture and extend each participant's unique encounter. These post-experience anchors transform a private immersive moment into a shared conversational resource, serving both personal commemoration and the community cohesion goals that motivate VR's integration into group musicking.

5.2.3 Design for Communication Across Roles: Wearers, Bystanders, and Facilitators. Community musicking is inherently collective, and social VR holds considerable promise for shared immersive participation [5, 7, 105]. Yet practical constraints in real-world aged care settings, including device availability, staffing, ethical considerations, and varying resident abilities, mean that VR will often be used individually or in small groups by turns [87, 90], and wearers will inevitably encounter co-located bystanders and facilitators they need or want to connect with [64]. Designing for this requires deliberate attention to the full social configuration of a session: when VR becomes socially opaque it risks fragmenting group dynamics, but when designed to be legible and responsive to co-located others, it can create dialogue-rich spaces at the boundary of virtuality and reality, fostering meaningful exchange across roles [98, 104].

Our findings illustrate how this multi-role dynamic can be generative. During Phase 2 sessions, co-located participants responded naturally to what they observed via the casting display: P3, while watching P2's experience, began moving to the music and spontaneously shared memories of his time studying in the Soviet Union with others. Bystander residents who observe and engage in such ways may also gradually develop their own readiness to wear the headset in future sessions [64]. For facilitators, T2 reflected that VR could offer younger practitioners a window into the lived texture of elders' pasts in ways that words and photographs cannot fully convey, positioning VR as a medium for cross-generational communication within the therapeutic relationship.

Design should therefore provide mechanisms that support communication across different roles, such as keeping real-world voices and exchanges present without disrupting the wearer's immersion. Bystanders need ways to remain meaningfully involved rather than passively waiting; casting displays, shared audio, and facilitated discussion anchors can be further designed to sustain their engagement. Facilitators need tools to guide pacing, monitor emotional responses, and safely exit experiences when content triggers distress; the Safe Room mechanism and sound-based transitional cues identified in our workshops are concrete instantiations of this function and should be treated as core infrastructure rather than optional features [87, 98]. Emerging research has begun exploring ways to support bystander awareness across the HMD boundary [43, 64], but these approaches have yet to be applied in community-based settings with older adults, representing an important direction for future work.

5.2.4 Designing for Harmony, "Impossible Musicking," and Culturally Situated Identity. For many participants, musicking was not merely a recreational activity but a practice of self-cultivation and aspiration toward a richer, more meaningful and expansive engagement with music, others, and the world [18, 30]. We propose *harmony* as a lens for understanding the experiential quality that participants sought in VR musicking, and as a design goal that extends beyond functional accessibility. Harmony, in this sense, operates across multiple dimensions.

At the sonic level, participants valued the precision of choral blend and collective attunement, as well as the restorative quality of congruent natural soundscapes, suggesting that careful attention to musical and ambient audio design is foundational to a resonant VR musicking experience [48, 89]. At the multisensory and interactive level, participants sought liveness and responsive dialogue: environments that felt alive and reacted to their presence, where visual representation, spatial design, and sonic experience cohered into an integrated whole rather than a collection of disconnected elements [91, 104]. At the experiential level, participants aspired toward what we term *impossible musicking*: VR as a medium for wish fulfillment, enabling musical encounters that were impossible in participants' actual lives due to physical limitation, geography, or historical circumstance, and supporting experiences of self-transcendence, awe, and positive transformation [40, 54, 56, 92].

These aspirations are culturally and biographically situated. The specific anchors observed in this study reflect the historical experiences of this generation of Chinese older adults, including classical repertoire preferences, Chinese instrument traditions, and aesthetic and spiritual ideals rooted in Confucian and Daoist thought. These are not universal referents; designers working in other socio-cultural contexts should identify the musical values and biographical anchors that hold meaning for their specific community [52, 91].

5.2.5 Designing for Optimal Presence: Calibrating Immersion and Supporting Reality-Virtuality Transitions. A common assumption in VR design is that deeper immersion produces better experiences. Our findings complicate this. Participants' responses to the Memory Train scenario revealed that high-fidelity historical reconstruction can work against its own goals: immersive historical content may trigger associations with tedium, hardship, and trauma rather than intended nostalgia. P9 articulated this tension directly, arguing that authentic virtual experience requires prior lived understanding: without that foundation, immersion alone cannot produce meaningful engagement. These findings support a shift from designing for maximal presence toward designing for *optimal presence*: a state in which immersion depth remains controllable and responsive to individual emotional needs [28, 73, 74]. Rather than maximizing sensory enclosure, optimal presence involves a calibrated balance that allows participants to maintain spatial orientation and emotional safety without disrupting engagement.

Supporting this requires careful attention to transitions between the real and virtual worlds. Research suggests that active user control over scene entry yields higher presence and better experience for older adults than passive transitions [42], and that smooth bi-directional transitions are essential for maintaining UX continuity and preventing spatial disorientation [35]. In community care settings, however, older adults may need facilitator support to navigate

these transitions safely: therapists should be positioned as gatekeepers with tools to pace, monitor, and adjust transitions accordingly. Sound offers a particularly effective medium for both user-initiated and facilitator-guided transitions: familiar audio cues can serve as low-burden previews, easing participants gently into a virtual environment and guiding them safely out without abrupt perceptual disconnection. The Safe Room concept and sound-based entry and exit signals proposed by therapists in our workshops are concrete instantiations of these principles and should be treated as core design infrastructure rather than optional safety add-ons.

This implication connects directly to Section 5.2.1. Musical biography elicitation is not only useful for content personalization; it is also the mechanism through which facilitators can anticipate emotional boundaries before a session begins and calibrate immersion depth accordingly. Co-design with both older adults and therapists is therefore essential not only for generating scenario content, but for establishing the safety parameters that make deep immersion responsible rather than risky [91, 98].

6 Limitations and Future Work

Our study has several limitations. First, our recruitment primarily included older adults without cognitive impairments who were largely independent and technologically receptive within a high-end CCRC in a first-tier Chinese city [44, 96], whose socioeconomic and educational profiles exceed the national average. The community music program at our study site reflects a level of professional staffing and institutional investment that is not yet widely available across Chinese aged care settings [63], which may limit the generalizability of our findings to more typical community contexts. Second, HMD-based VR carries accessibility constraints, excluding individuals with significant visual impairments or discomfort from prolonged headset wear. Recent work on support structures for seated VR [8] points to a complementary direction where hardware adaptation and contextual activity design can advance together. Our study also focused on locally facilitated experiences and did not explore social VR or alternative immersive modalities such as projection-based and shared-screen formats, which future research should investigate as complementary supports within care practices.

While our findings are situated within a resource-rich context, the tensions and design opportunities they reveal speak to broader questions in HCI and aged care practice about how immersive technologies can be integrated into community life in ways that respect older adults' diverse motivations, cultural identities, and social ecologies. As aging populations worldwide increasingly seek technologies that support holistic wellbeing rather than deficit compensation, this work offers an early and situated contribution to that conversation.

Future work will transition from envisioning into iterative prototype development and evaluation, maintaining deep involvement of older adults, music therapists, and other stakeholders such as family members and care workers to ensure the sustainability of immersive music interventions [84, 92, 95].

7 Conclusion

This study engaged older adults and music therapists at a Chinese CCRC to investigate how immersive VR might support meaningful musical engagement within existing community practices. Through a participatory field study involving observations, interviews, VR first experience sessions, and co-design workshops, we moved beyond functional-assistive paradigms to understand VR as a situated complement within the social ecology of community musicking. Our findings reveal how older adults' biographical histories, aesthetic values, and cultural identities shape their perceptions of and aspirations for VR, and how music therapists navigate enthusiasm for technology's potential alongside concerns for safety, facilitation, and community integration. We propose design implications centered on musical biography as a design material, harmony and impossible musicking as experiential goals, shareable artifacts that extend VR's value beyond the session, communication across wearers, bystanders, and facilitators, and optimal presence over maximal immersion. This work contributes a multi-stakeholder, culturally situated account of immersive VR in community music practice, demonstrating that meaningful integration requires attending not only to individual experience but to the social ecologies, relational dynamics, and diverse aspirations of the communities into which technology is introduced.

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A Appendices

A.1 Revised Storyboards: Therapist Versions

Following the co-creation workshops with older adult participants, we revised each of the three VR scenarios to address specific design concerns raised during the evaluation of the initial storyboards (Scenarios 1A–3A). In the subsequent therapist evaluation sessions, therapists were presented with both the original (A) and revised (B) versions of each storyboard, and we explained the rationale behind each design change based on the older adults’ feedback. Below we present the updated “Therapist Version” storyboards (Scenarios 1B–3B), each accompanied by a brief rationale for the key design changes.

A.1.1 Scenario 1B: Memory Station. P2 and P14 noted that train travel in their lived experience was often tedious and exhausting rather than poetic, suggesting the original metaphor could anchor users to unpleasant sensations. We therefore replaced the train setting with a childhood radio station, foregrounding music and sonic interaction as the primary reminiscence triggers.

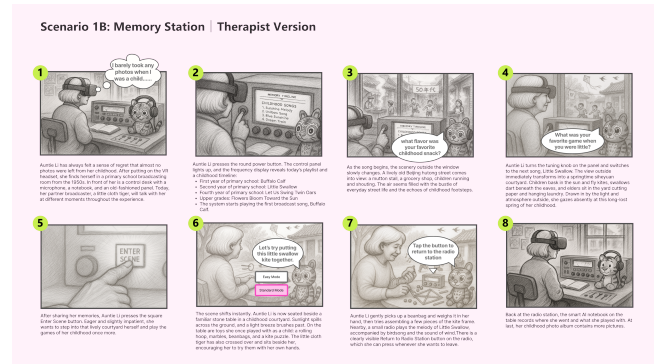


Figure 7: Revised storyboard for Scenario 1B (Memory Station, Therapist Version). The train metaphor is replaced by a childhood radio station to foreground music-driven reminiscence.

A.1.2 Scenario 2B: Ensemble Band. P1 criticized the original design as lacking educational depth, and P15 emphasized the need for background on compositions and instruments. In response, we introduced contextual knowledge panels (Panel 5) that provide instrument history, the piece’s role in the selected composition, and performance tips.

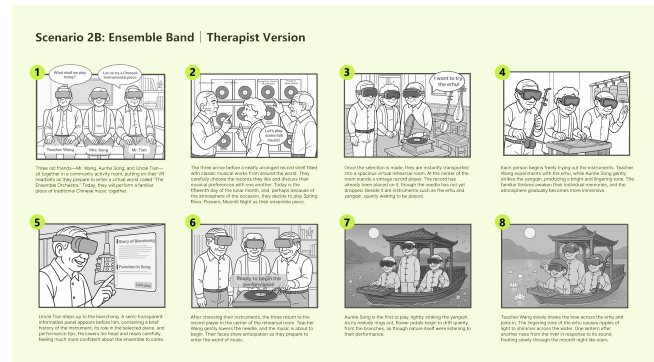


Figure 8: Revised storyboard for Scenario 2B (Ensemble Band, Therapist Version). A contextual knowledge panel is added to support participants’ desire for intellectual engagement.

A.1.3 Scenario 3B: Natural Sound Island. Participants reported that the explicit control panel disrupted experiential immersion. We removed the visible UI overlay and replaced menu-based navigation with embodied interactions and ambient AI voice-over cues for scene transitions.

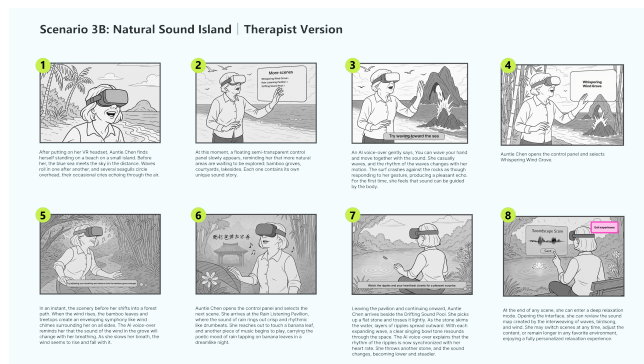


Figure 9: Revised storyboard for Scenario 3B (Natural Sound Island, Therapist Version). The control panel is removed in favor of embodied and voice-guided scene transitions.

A.2 VR First Experience Process and Demo Materials

Each VR First Experience session began with an introduction to HMD-based VR, followed by exposure to three categories of demo content selected to reflect participants' musical interests and biographical backgrounds: (1) 360-degree music performance experiences, including orchestral concerts, folk performances, and culturally resonant scenes; (2) travel and nature experiences with soundscapes, such as guided meditation and nature immersion; and (3) interactive music experiences, such as virtual conducting and drumming. Sessions concluded with post-activity in-depth interviews ($N = 15$). Figure 10 provides an overview of the session structure and demo materials used.



Figure 10: Overview of the VR First Experience session, including demo materials across three content categories and post-activity interviews.