Message in a Bottle: Investigating Bioart Installations as a Transdisciplinary Means of Community Engagement

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ABSTRACT

As exploration of living media, biology, and biotechnology advances HCI, researchers call attention to implications for ethics. We respond with a qualitative study of audience engagement with multimedia bioart installation. Bioart comprises a transdisciplinary practice that brings diverse perspectives in art, science, and technology into dialogue and engages audiences. Understanding a bioart exemplar, *Raaz*, as disrupting habitual modes of being, we investigate audience experiences in three contexts, elaborating transdisciplinary community engagement that takes seriously living media and biotechnology and informs HCI broadly through vital authenticity, performative reflection, empowered critique, distributed expertise, and revealed dynamics. We discuss how transdisciplinary community engagement functions as a mode of inquiry and design that supports inclusive liminal experiences.

CCS CONCEPTS

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

KEYWORDS

Living media interfaces, bioart, installations, DIYbio, community science, synthetic biology

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1 INTRODUCTION

Art can serve as a practice of knowledge generation that supports the development and communication of ideas that engage complex or difficult aspects of human experience using accessible language [85]. This knowledge can be challenging to integrate into practice for research communities, even those that embrace interdisciplinarity such as human-computer interaction (HCI) [49]. The role of art in HCI research is contested and evolving [11, 21, 53], but investigating this relationship can serve as inspiration and as a means of understanding interaction and the broader social world, giving rise to novel design research methods (e.g., cultural probes [40]), interaction modalities (e.g., tangible user interfaces [50]), and interaction paradigms (e.g., the enactive approach [94]). Human-computer interaction has also turned to art to facilitate participatory engagement in design [20, 32, 96] and critical thinking [78], and more recently to bioart as a transdisciplinary mode of inquiry exploring the boundaries of interactive technology [3, 44, 103]. This framing draws on Blevis and Stolterman's definition of transdisciplinarity as knowledge production that pursues socially relevant outcomes by drawing on "collections of methods and their associated domains of expertise" [13, p. 5] with the goal of transcending the demands of disciplinarity [44]. Often, HCI's engagement with art informs and builds on research that looks to design outcomes other than commercial products [34]. Influential among these are the design and development of publics [30, 61, 62] and future relations [65].

The term *bioart* is contested [5, 76]. In this paper, we refer to art created using the tools and materials of biological sciences as bioart. Recent research has explored the intersection of bioart and HCI through hands-on projects [3, 44, 57, 58, 103], meta-analysis of bioart and biodesign perspectives [75], and interview studies with bioartists and biodesigners [7, 44]. In this study, we contribute to the conversation between HCI and bioart by presenting results from a qualitative study of audience experience with a multimedia bioart installation, *Raaz*, through which we analyze perceptions of the installation and reflections on the personal and social significance of the gene editing practice that enabled and is reflected and critiqued by the artwork. Early research has indicated that bioart can be a means of facilitating community engagement (CE) [97]. The current work aims to explore the mechanisms by which bioart as a transdisciplinary creative practice may contribute to the

engagement of diverse communities in conversation about the past, present, and future of science and technology. This conversation is essential to the development of an inclusive and dynamic critical perspective on HCI.

The empirical fieldwork we report in this paper describes how three audiences interacted with bioart in distinct settings, their views on their experience, and reflections on related issues. We describe five aspects of how audience experiences with bioart unfold and take shape, which collectively outline how bioart works as a means of CE. We argue that the transdisciplinarity of bioart converges with practices of CE, extending knowledge about making community and exposing issues of concern that can enhance practice. Finally, we discuss the role and potential of *liminality*, a transformational and transitory state that occurs in the space between two stable states [101], as a space where transdisciplinary community engagement can support participation. Liminality is one salient quality among many possible areas for future investigation our study offers. A frequent theme in art and creative expression, we discuss how engaging with liminality can connect HCI and knowledge generated through art and open rooms of the HCI community to critical and inclusive research practices.

2 BACKGROUND

We describe the scientific and technical context of *Raaz* as a tool for interrogating emerging technology such as synthetic biology, bio-HCI, and living media interfaces (LMI) [74]. We look to the literature on community engagement in HCI to review current understandings of its aims, methods, and challenges. We understand our work as situated within these, using bioart to facilitate CE both in general and with regard to the technology it utilizes, reflects, and critiques.

2.1 Bio-HCI and Living Media Systems

A growing body of HCI research is investigating the possibilities of incorporating living organisms into the design of interactive artifacts and experiences. In a review of living media interfaces (LMIs) that combine living organisms with digital components, Merritt et al. [75] identified projects that incorporate digital components with a range of living organisms in almost every biological kingdom, which has since expanded. Living media interfaces expose cultural and material circumstances; examples include the notion of collaborative survival exposed by perception of human-fungi relationships [66], a taxonomy of "livingness" in LMI design [55]; exploration of temporality through the "cyano-chromic interface" [109]; how a wearable slime mold computer can motivate care [69]; and how changes in fungi growth can visualize data and engage children over time [42, 43]. It is argued that living media are especially suited for the representation and communication of environmental and ecological data [46] and interpersonal communication [19]. With a shift in perspective, interaction and computing technologies such as electrical muscle stimulation [67, 68], brain-computer interfaces [81, 107], and affective computing [14, 17] demonstrate how a human user might arguably become a living media interface or system.

The notion of bio-HCI incorporates biological media as interfaces as well as looks to advances in biotechnology for possible implications for computational system and interaction design [83], such as DNA data storage [54]. While a number of LMI designs explore microorganisms [19, 63, 82, 108, 109], hands-on exploration of biotechnology such as synthetic biology–the creation of altogether new genes and their insertion into living organisms [93]–has primarily been in the realm of bioart [3, 44, 103], a method of inquiry into emerging biotechnology and other intersections between science and technology [74].

Several ongoing efforts call for more research on questions of ethics and equity in the space. For example, the animal-computer interaction research community is focused on designing interactive systems for, with, and by nonhuman animals [71]. A central theme within this space is how to account for animal agency and include them in a participatory manner in the design process (e.g., [86, 87]) a call that is not uncontroversial [60]. Pataranutaporn et al. [83] propose that microbes can be viewed as "programmable biological interfaces" with unique affordances for HCI applications, including the ability to store (i.e., embody) and communicate information and respond to bio-fabrication processes, among others. However, they also point out that technical, ethical, societal, and environmental challenges remain in this space, and draw on new understandings in bioethics that call for prioritizing public beneficence, democratic deliberation, and justice and fairness, among others. Given the gravity of these technological and design developments (as they impact questions of life and death), public and community-engaged exploration of issues of concern and possible responses in the domain of bio-HCI and living media systems are under explored.

2.2 Participation and Community Engagement

Community engagement is a prominent focus of research and practice in many fields, defined by the US Centers for Disease Control and Prevention as, "the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people" [72]. In public health and medicine, CE is strongly advocated as essential to quality practice [47, 72, 80]; university-based initiatives prioritize and debate CE through research and service learning [24, 38, 77]; and communication, public relations, and businesses grapple critically with the meaning and role of CE in their fields [16, 28, 52]. In human-centered computing fields such as HCI, interaction design, and computer-supported cooperative work, CE proliferates in directions similar to those in the aforementioned fields, such as empowerment theory [37, 92], cultural heritage [9, 39, 106], and municipal governance through the lens of digital civics [6, 22]. As an aspect of civics and participatory democracy, CE, in dialogue with participatory design, has extended our understanding of publics in human-centered computing research and practice, positioning the development of publics as an alternative to the development of products [31, 36, 39, 61]. The development of publics—both with aspirations of designing and using technology as well as addressing issues raised by technology—has been productively explored in urban [6, 22] and rural [9, 18] computing, information, and communication systems, within defined contexts of engagement.

Approaches to CE in human-centered computing are varied and include design techniques [33, 98], critical participatory design

[100], making [10, 39, 99], participatory art [20, 32, 96], participatory research [6, 84], and action research [9]. While early research indicates that bioart may facilitate CE [97], we do not know the mechanisms by which this might occur or potential outcomes. Successful CE initiatives sometimes must overcome barriers to participation related to the experience and positionality of the researchers and practitioners involved, in particular in relation to communities affected by systemic oppression. Projects that acknowledge injustice and promote researcher self-reflection and the development of allyship can move in more participatory directions [45, 79]. As community and individual experiences are diverse and intersectional [25, 91], one approach to equitable and participatory CE could involve the development of modalities sensitive to and supportive of diverse experience. Our work seeks to contribute to this body of knowledge by illuminating transdisciplinary means of inclusive engagement.

3 STUDY DESIGN

Our study investigates audience experience of a multimedia bioart installation in three community contexts. Below, we describe the artwork and events and our data generation protocol, analytic approach, and positionality.

3.1 Multimedia Bioart Installation as a Means of Community Engagement

The ideation, development, and implementation of biological processes that were used to create the multimedia bioart installation took place at the community lab that served as the first event site (described below). Community biology labs are organizations that provide informal learning experiences in biology and related areas, such as biodesign, DIYbio, and bioart to community members, and are found to enable multiple forms of engagement and learning [29, 105].

Raaz (a Farsi word meaning "secret" or "mystery") is a bioart installation that creates a poetic, meditative space with transmedia embodied representations of a canonical poem on love and transformation by the 14th-century Persian Sufi poet, Hafiz of Shiraz. At the center of the installation is a poetry-infused bottle of transgenic wine surrounded by large-print microscopic images of genetically modified yeast used to make the wine and whose genome includes an encoding of the poem. The wine was made by, (1) converting the poem into a viable DNA sequence, (2) having the DNA sequence synthesized and inserting it into a plasmid (circular DNA capable of propagating the inserted DNA in cells), (3) transforming living yeast cells using the plasmid and verifying that their DNA carries the synthesized code, and (4) growing the transgenic yeast and using it to ferment grape juice into wine [44]. The poem captures ideas about love, transformation, and time. A translation by the artist follows: *"One whose heart is vitalized by love never dies / Our continuity is written on the face of time."* An audio track inspired by Alvin Lucier's *I Am Sitting in a Room* (1969) combines the reading of the poem, its Morse code representation, and a bass flute melody, which surrounds the installation. Thus, audience members encounter the poem in several translated forms. *Raaz* was created by a transdisciplinary team of artists and scientists with expertise in interaction and audio design, biology, and scientific imaging [97].

Raaz is part of a bioart tradition that explores the significance of storing text in living organisms. Exemplars include Eduardo Kac's *Genesis* (1999), in which the artist encoded a line from the Book of Genesis as DNA, then inserted into the genome of living bacteria upon which audience members could shine a UV light (both in the gallery and over the Internet) to cause genetic mutations; Joe Davis' *Malus ecclesia* (2014), in which the Wikipedia article for "Good and Evil" was encoded into the genome of an apple (with the intent to eventually encode the entire English Wikipedia), "genetically modifying an apple to tempt the Devil" and pushing the boundaries of how much data can viably be synthesized and stored in DNA [102]; and Sarah Khan and Joe Davis' *Baitul Ma'mur: House of Angels* (2021), in which the artists encoded an Arabic prayer as DNA and inserted it into the genome of bacteria placed on a pinhead. *Raaz* builds on and extends these bioart projects by engaging the cultural significance of wine and fermentation, which, though intoxicants are forbidden by Islam, are frequently invoked by poets in the Sufi tradition as a metaphor for dangerous yet necessary spiritual transformation. By turning the metaphor of wine into material reality, *Raaz*'s engagement with the process of winemaking parallels the ethically ambiguous practice of genetically modifying living organisms. *Raaz* further contributes to diversifying bioart by bringing in a non-Western perspective to a space dominated by Western perspectives and by embodying a meditation on identity and culture in transition as Persian poetry is transformed into a new embodied form in a new context (i.e., Eastern United States).

3.2 Event Descriptions

Our study took place at three sites: a community lab, a university music department, and a university information systems department (Figure 1). At each event, the main component was the multimedia installation *Raaz*, accompanied by an artist talk and data generation activities. Each event was an opportunity to iterate on the artwork experience, exploring variation informed by meanings and possibilities afforded by each space. Each event maintained internal consistency between the space and the audience and each is connected by the continuity of the artwork, artist talk, and data generation protocol. This allows us to look at patterns in audience experience with a flexible and lightly customizable art experience that invites exploration and reflection from different perspectives.

All events included a talk by the principal artist, the composer who created the audio for the installation, and the sound engineer who recorded and spatialized the audio. Presentations included discussion of inspiration and meaning extending beyond presenters' disciplinary expertise, breaking from traditional academic norms. The principal artist described the concept and the biological and artistic process that resulted in the wine. Collaborators took turns discussing their contribution to the project, using slides and audio samples to illustrate their processes. Talks were followed by a brief Q&A period.

In the following subsections, we present the context of each event. Event details are described by site in Table 1.

3.2.1 Site 1: Baltimore Underground Science Space. Hosting a community bioart event at the Baltimore Underground Science Space (BUGSS) is not out of the ordinary. The event, held on a Saturday evening, was publicized to members of the BUGSS community via

Table 1: Bioart Events

Site	Date	Audience	Site features	Installation	Artist talk
Baltimore Underground Science Space (Site 1)	Oct. 2021 (1 day)	Lab members, public (approx. 20)	BSL-1 nonprofit, volunteer-run community biology lab in an urban neighborhood in a mid-sized city; members learn about and do biology; seminars on topics such as climate change, digital equity, agriculture, and health. Wet lab open for agar art activity.	Sound affected by industrial interior; bright, fluorescent lighting; audio in Farsi only.	Talk held in the front room typically used for classes, meetings, or seminars. Light refreshments.
Livewire Music Festival at UMBC (Site 2)	Oct. 2021 (2 days)	Music students, university community, public (approx. 50)	Annual music festival at small R1 university outside a mid-sized city features performances, artist talks, and installations; some music students required to attend.	Optimized audio; dim and isolated space; poster describing the transformation of the poem into DNA code; audio in Farsi and English.	Included presentation by microscopy artist; held outdoors, some distance from the installation.
Interactive Systems Research Center at UMBC (Site 3)	Mar. 2022 (2 days)	Information and computing technology students, faculty (approx. 20)	Department in small R1 university outside a mid-sized city offers data science, business technology, and HCI degrees; research includes usability, accessibility, and privacy; typical events include technical research presentations and student poster competitions; occasional collaboration with arts departments, e.g., dance and imaging.	Dim with blue and magenta lighting; a treadmill remained in a corner; motion-capture cameras remained mounted on the ceiling; a smart screen was incorporated into the installation, displaying a montage of images; poster describing the transformation of the poem into DNA code; audio in Farsi and English.	Talk held in a classroom adjacent to the installation; several attendees did not attend the talk.

Figure 1: Audience during artist talks at each of the three sites. From left to right: site 1 (BUGSS), site 2 (Livewire Music Festival at UMBC), and site 3 (Interactive Systems Research Center at UMBC).

electronic newsletter and social media and to the broader Baltimore community via a city-wide art events calendar. The space had three main areas open to audience members. The first space, where participants entered the building, was set up with chairs facing a corner where the artists gave a presentation. The second space, adjacent to the first, contained the *Raaz* installation (Figure 2). The lab is in an old industrial building with high ceilings and exposed brick and vents, and the room was empty other than a few cabinets. The third space was a wet lab with equipment and benches set up for audience members to paint on agar plates using bacterial and yeast microorganisms nearly invisible during application, but which express pigment over time [2]. The university-based researchers and community lab-based researcher have collaborated on projects, including the current one, for the past four years. Interviews were conducted in the space where the talk had been and in the wet lab.

3.2.2 Site 2. Livewire Music Festival at UMBC. The second site was the Department of Music at the University of Maryland, Baltimore County (UMBC), where the artists were invited to exhibit the work as part of an annual music festival. The event was advertised to the university through fliers and email groups.

Two spaces were used for this event. The artist talk took place on Friday afternoon outside under a covered patio next to the music building to minimize large indoor gathering during the COVID-19

Figure 2: At site 1, attendees and artists in the installation space exploring and discussing the artwork.

Figure 3: At site 2, an attendee sits in front of the bottle of transgenic wine surrounded by the audio and images.

pandemic. After the talk, audience members were invited inside the building and up a flight of stairs to a conference room transformed into the installation. Due to COVID-19 precautions, attendees waited outside the room to enter in groups of 2-3 (Figure 3). Interviews were conducted with participants in the hallway outside the conference room.

3.2.3 Site 3: Interactive Systems Research Center at UMBC. The final event was held at the Interactive Systems Research Center, a research center situated in the Department of Information Systems at UMBC) focused on HCI research. The event was held on a Thursday evening with the installation open through noon on Friday. The artwork was installed in a large user studies laboratory on the fourth (top) floor of the building, featuring a one-way mirror and adjacent observation room used for the audio equipment. The lab is off a main hallway that anyone on the floor must walk through to enter or exit (Figure 4).

The event was advertised via email and an electronic flyer, primarily targeting individuals in the Information Systems and Computer Science and Electrical Engineering departments. While the

Figure 4: At site 3, attendees stand around the installation space, facing the transgenic wine and smart screen, quietly listening and observing. The lighting at site 3 illuminated the one-way mirror of the observation room, emphasizing the provocation of liminality in the traditional HCI research space.

event was held in the evening to avoid conflicts due to class schedules, about half of the approximately 20 attendees did not attend the talk. Interviews were conducted with participants in the hallway or classroom where the talk was held.

3.3 Participants

In addition to observation, we collected interview and survey data from 26 participants. The event at site 1 was physically contained; nearly all audience attendees completed a questionnaire and most participated in an interview. At site 2, many more people attended the event than participated in an interview, and distributing the questionnaire was less effective due to spatial constraints. At site 3, approximately one third of attendees participated in an interview, with a few more completing a questionnaire.

Half of participants self-identified racial or ethnic identity other than white, and an approximately equal number of self-identified female and male individuals participated. The average age of participants is 37 years (range 20-71). Additional personal information was not systematically solicited, however, participants offered perspectives explicitly informed by race, ethnicity, nationality, gender, sexual orientation, and disability in interviews. While the events attracted a diverse audience, demographic characteristics are distributed unevenly across events (Table 2). Additionally, participants at the event at the community lab (site 1) reported a broader range of occupational backgrounds compared with participants recruited in the university settings (sites 2 and 3). This is expected, as the university events were promoted among students and faculty in programs that housed the events (i.e., Music and Information Systems/Computer Science), and the university is located outside Baltimore city, meanwhile the event in the community lab was more accessible to members of the general public.

Table 2: Participant Information

Participant ID	Age	Gender	Race or Ethnicity	Occupation
CL1	53	Male	Caucasian	Glass worker
CL2	39	Female	White	English to speakers of other languages (ESOL) instructor
CL3	30	Male	White	Marketing analyst
CL4[a]	41	Female	White	Client engagement manager at legal firm
CL5[a]	64	Male	White	Acupuncturist
CL6	34	Female	Black	Nurse
CL7	36	Male	White	Project manager
CL8	28	Male	White	Software engineer
CL9	43	Female	White	Self-employed
CL10[b]	40	Male	Persian	Web and interactive media
CL11[b]	71	Female	White	Retired
Mus1[c]	27	Female	South Asian	Intermedia and digital art graduate student
Mus2[c]	37	Female	White	Musician
Mus3	21	Male	White	Music undergraduate student
Mus4[c]	20	Female	African American	Music and math undergraduate student
Mus5[c]	23	Male	Black	Singer and post-graduate music student
Mus6	46	Female	Asian	Information systems professor
IT1	50	Female	Hispanic	Mechanical engineering professor
IT2	33	Male	Asian	Computer science graduate student
IT3	28	Female	Asian	HCI graduate student
IT4	22	Female	White	Individualized studies and animation undergraduate student
IT5	52	Male	Caucasian	College administrator and HCI professor
IT6	31	Male	Iranian	Computer engineering graduate student
IT7[b]	40	Male	Black African	Information systems graduate student
IT8[b]	29	Male	South Asian	Information systems graduate student
IT9[b]	30	Male	Black	Information systems graduate student

[a] Interviewed together. [b] Completed questionnaire but did not participate in an interview. [c] Participated in interview but did not complete a questionnaire.

3.4 Data Generation and Analysis

Three public events were held over a span of six months (October 2021 to March 2022) wherein the multimedia bioart work was exhibited for one or two days (see Table 1 for event details). Inspired by the study of culturally rich multimedia HCI in museums [48], we generated data using brief in-situ interviews, questionnaires, and participant observation during all events.

At each event, we announced that the event involved a research study, identified members of the research team to attendees, and stated that we would be taking observational notes and photographs. We invited anyone who did not want to be included to identify themselves so we could avoid including them in published observation photographs or notes. If anyone did not want to participate in the research, they could still experience the events. No audience members asked to be excluded from observation. Our protocol, which included a verbal informed consent process, was reviewed and approved by the UMBC Institutional Review Board. We provided attendees printed information about our research study. We also received permission from the community lab's Board of Directors to collect data for research purposes prior to data collection.

Data generation activities were conducted by the first, second, and third authors, who were not involved in the artistic process. Semi-structured interviews with participants included questions about art, science, identity, and learning. Interviews were audio recorded and transcribed. Example questions include, "Thinking about this event and about *Raaz*, complete this sentence: The artwork reminded me of..." and "What do you hope the artists will do next with their work?" Average interview length was 8 minutes. Researchers also made contemporaneous jottings and recorded longer descriptive and reflective field notes. The second author (Prottoy) took photos. Participants also completed a questionnaire with multiple-choice questions about background and experience and open-ended questions about their experience at the event. Example questions include, "Can you imagine using your skills, resources, or expertise to contribute to a (bio)art project? If yes, in what ways would you contribute? If no, why not?" and "If you continue thinking about one or two aspects of *Raaz* in the coming days, what might they be?" The questionnaire was printed and included in a handout that provided information about *Raaz*. The instruments are provided in Appendices 1-3.

To understand qualities of participant experience as they relate to community engagement, we conducted a thematic analysis. We used inductive, open coding across all data to explore patterns of meaning and organizing concepts. Codes were compared and organized into groups with shared meaning. Example open codes used include, "immersive experience," "identity as a decision," "presentation directing attention," and "drawing on past experience." The first author (Stamato) constructed and wrote the themes. The first

and last authors (Stamato and Hamidi) continuously discussed the themes and the last author also contributed to their refinement and writing.

3.5 Researchers' Positionality

The first, second, third, and last authors (Stamato, Prottoy, Higgins, Hamidi) have expertise in HCI and are currently based at the University of Maryland, Baltimore County (UMBC), a university in the Eastern United States where events at sites 2 and 3 took place. The fourth author (Scheifele) is an expert in biology and informal learning and serves both as the Executive Director of the Baltimore Underground Science Space (BUGSS) and as biology faculty in Loyola University Maryland, another local university. The first author is originally from the United States and is not of Persian or Iranian background and the last author is originally from the Middle East. The last author is also the principal bioartist who created and conceived *Raaz* and the three events that are the focus of this paper.

4 FINDINGS

Everyone we spoke with spontaneously described at least one thing that interested them about the work, and many participants showed or recounted diverse emotional responses to *Raaz*, such as fear, interest, and joy, which contribute to the themes herein. In this sense, the experience successfully engaged audience members. Our analysis provides insight into the nature of this engagement and its implications for understanding bioart as a means of community engagement. We describe five experiential modalities through which bioart installation may work as a transdisciplinary means of community engagement: (1) vital authenticity, (2) performative reflection, (3) empowered critique, (4) distributed expertise, and (5) revealed dynamics.

4.1 Vital Authenticity

Vital authenticity describes the affects and ideas participants found or generated through encounter with bioart installation in their community. In this section, we develop an understanding of vital authenticity with a focus on its connection with audience concerns regarding process orientation and change.

Presented as a work of art rather than a work of design, we observed that *Raaz* supported audiences in noticing processes undergone in the work (e.g., translation, transformation, fermentation) and did not usually lead participants toward any particular analysis regarding meaning or purpose. For example, CL1 appreciated how, "there is no particular outcome that's expected or experience for the observer or participant." Contemplating the project's beginnings, Mus1 explained: "It's not just regular wine. And the whole process; I want to know how [the artist] thought about the start of a project like that." However, participants shared different reflections on the temporal aspects of the process. For example, some described the wine as "the final product," and imagined commercial products and services using gene editing technology to produce human language-infused wine.

Participants spoke about the vitality of *Raaz* and (at site 1) of the pigmented bacteria and yeast and connected these with experiences of vitality in everyday life. After considering for a moment, CL6 said, "I just like the idea of making the poem alive and bringing back that history that could feel really distant into something living and here and material." Comparing the bioart installation to a photography exhibition, CL8 said, "The living art felt like it was going to change as I was looking at it. Whereas the photographs felt like they were capturing the '90s but still around me it was 2021." Mus1 described how elements of the installation amplified the sense of vitality:

> "I think it's interesting how the wine glasses are placed on sound box[es]. I'm not sure if there is any effect on the glass, like they have a certain frequency the glass will shake. I'm not sure about that. [...] Because it seems like the glass has some kind of life. Like the whole process. Like in the wine, we thought that it's dead but it has some bacteria in it which is kind of alive. So, the whole process is kind of- seems like dead, but that has life."

CL2, who described feelings of fear and creepiness in their encounter with the installation, described a change in perception during hands-on engagement with genetically modified organisms in the wet lab, indicating the potential for hands-on experience to affect perception of ethical action within experience of vitality:

> CL2: I thought it was kind of funny like here I was kind of like perturbed, you know, with the initial installation, and then I was all for taking this bacteria and I was like 'Yes!' So, like, zero qualms as I was doing that.
> Interviewer: So how do you feel about that?
> CL2: [Laugh] I don't know. I didn't mine that too deeply.

The vitality of bioart and biotechnology as a medium are also connected to the artists' intention and hand, connecting creators and change. Mus1 described biology and nature as sources of inspiration: "We get inspiration from people, the environment, nature, so I think biology is not excluded from it." Mus2 described how these can function as media:

> "[Biology] is a way to understand the artist in this case, because the way that this particular artist is expressing himself is through this biological process or manipulation. So, it's that specific piece of it that makes it his self-expression. Just like a painter would have a visual representation in that specific way, the paint is the medium with which the artist can express himself or herself. The biology is kind of the mode of expression."

Participants' experience of the vitality of bioart as a medium appears to support reflection on the vitality of the makers involved, often described as interest in *authenticity* as a connection between the two. Authenticity was described as an attribute of the artwork, evidenced in part by uniqueness and beauty: "I rarely see people, I don't know, show this picture, this cell being illuminated and it's so beautiful, and it is authentic. And it was making the yeast from poem, and uhh! It's just very mind-blowing. And also, it's very unique" (Mus6). That engagement with bioart can be "mind-blowing," understood as able to significantly defy expectations, points to the necessity of a change in perspective with respect to expectations, and positions engagement with bioart as entry to

engagement with liminality. While Mus6 noted the role of the yeast in creating this effect, they did not expand on the impact of vitality specifically. Rather, they described a direct sense of vitality, "I never experienced this so close tight connect to the science into this really secret code of human life. Make it live and make it authentic feel[ing]."

Audience members also reflected on the biological and cultural elements of the work as metaphors, extending the vitality of bioart and of authenticity to their own experience. For example, IT5 described *Raaz* as a playful consideration of the relationship between "cultural DNA" and "actual DNA" that (per IT5) ultimately landed on culture in the form of wine. IT2, who grew up in India, reflected on the artwork's form and meaning by reflecting on personal experience: "The talk reminded me of home because Iran is closer to where I'm from. I don't know why, like maybe just some of the pictures there and just the explanation of [the principal artist's] experiences before kind of reminded me of home."

4.2 Performative Reflection

Raaz highlights the power of time through both form (gene editing) and content (chosen poem). The synergy of form and content afforded by bioart can be described as performative–it does/is the idea [8]. *Performative reflection* describes how the performative potential of art and of bioart in particular affected participants in their encounter with bioart installation in their community. In this section, we develop an understanding of how audiences experience performativity, how performativity engages perceptions of personal and collective identities, and how identity may catalyze reflection about personal and societal relationships with emerging technology in the past and future.

Participants described how perceived authenticity and creativity within the work of bioart differed from their other experiences with technology. For example, IT1 descried how art more generally can help with "reflecting on how [technology students] see technology, what responsibilities [it entails], and how they can use it for the betterment of the entire society." CL6 described how putting culturally constructed themes in dialogue with tools of science and biotechnology could have an effect: "Sometimes I think biology and science is really tied to the Enlightenment and white Western history. And so, it's nice to use it as a tool to explore race and identity and sort of subvert it that way." CL1 commented on the personal aspects of possible future understandings of genetics enabled by advances in biotechnology: "If you're genetically predisposed to whatever, I think that's definitely, you know, going to change your opinion of things in life, the universe and what's fair and what's not fair." IT4 described DNA embodying connections between the past and present lived experience, "DNA is related to ancestry, which is related to cultural history, which is also related to upbringing. [...] In the realm of disability, different issues with genetic disorders can lead to certain disabilities, which can lead to taking on the identity of being a disabled person. So, it can have both a historical impact and just like, 'here's what has happened in my family.' And you also get into the concept of generational trauma and whether that impacts DNA."

Many participants emphasized how encountering *Raaz* encouraged them to reflect on their own identity and relation to their personal and professional lives. As Mus6 described, "Artists are human, right? So, they are immersed in their cultural background, that then being necessary to their identity, their artistic identity, and the identity of the culture into the artistic product." IT3 shared how the experience helped them move from a previously static understanding of the meaning of identity to a more dynamic one:

> "From the biology that I remember, DNA is what is basically inside of every person, right? It constitutes of various elements which form us in the sense, like the basis for our existence. And so what I just saw, what I just witnessed, gave me a whole different perception of DNA and identity because I could not imagine such a form of DNA and identity. Because here from [the artist] talk it was trying to keep Hafiz's poetry timeless in existence. And that's so beautiful because of the DNA, for me, it was always linked to a person. But now it is something that I can view outside of a person and into an object, living or nonliving."

Also shifting beliefs in response to the experience of bioart, CL2 moved from an initial certainty about DNA as "the base of us all" toward a fluid and agential view, "when I reflect more on issues of identity and how we decide what and who we are, what and who we're interacting with." Describing their approach to research, IT6 explained the meaning of attention to detail: "The most important thing in my work [is] I try to be more detailed. I want to know as much as detail as I can remember about the work. That's how you value the importance of something, by knowing more detail about it." While this participant had not been to the community lab where *Raaz* began (event site 1), the notion that developing in-depth knowledge of the biological world can support appreciation and respect is embedded in its pedagogical philosophy, potentially extending engagement with vitality beyond what is typically considered alive.

Other participants had practical suggestions for how these reflections can be used to further change through learning. IT1 connected notions of constructed identity with professional identity and responsibility: "Something that I've been thinking a lot lately is the fact that art can be used for students to reflect on their identity as engineers and computing professionals, or students, and a way of exploring that." "Being true to yourself" (IT5) was also described as one of the most important things to learn in life: "We do our best work when we really care about it." IT2 echoed these sentiments through examples from their own life, saying in response to how this experience makes them think of their own identity, "The hope is to just be a good researcher. Good person. Yeah, think about how our work can help." Research on intentions to be helpful indicates the critical need for reflection [79], which the event surfaced.

Participants also indicated reflections on collective identity. Mus5, a performance artist, reflected on collaborative authorship and personal expression with respect to *Raaz*: "Like a play or singing, it's not necessarily about that artist. Yes, it goes through them. And yes, they do use their own experiences. But in general, it's about a wider story. I don't often see things as personal or directly relating to a specific personal experience of an artist." Mus6 described their perspective on the work's meaning, saying, "Love is universal. A love that the creator gives us- endowed to humanity. And I believe

love is the capacity of each human being." In this way, some audience members were able to bridge the cultural specificity of the artwork to concepts that they could relate to.

4.3 Empowered Critique

Empowered critique describes ways in which *Raaz* audiences engage with issues and questions encountered from their perspective and in their "language." In this section, we develop an account of how multimedia bioart installation events cultivated an inclusive and socially-oriented space for critique of science and technology.

We observed that *Raaz* events facilitated conversation among participants not previously acquainted, and turned interview participants toward social concerns. Participants expressed both critical and non-critical comments that were social in nature, illustrating the emergence of dialogue between audiences and art, science, design, research, one another, and the world. While these comments are as diverse as the audience, they often reflected a position regarding personal or social values.

IT3, who was not aware of the first event that combined agar art and *Raaz*, envisioned an event combining multiple bioart projects (thus, bringing transdisciplinary creators and their networks together with the audience), which might amplify the transformative effects experienced: "Maybe if you implement multiple bioart projects, it can really cause a ripple effect that would be beautiful to see." Further, reflecting on the transdisciplinary collaboration that produced *Raaz*, CL9 speculated that this method of work could constitute a "kind of community-based art."

These shared points of interest across audience members with diverse backgrounds in different settings highlight how bioart might facilitate collaboration between diverse people and communities on challenging and consequential issues. In conversation with ethics and morality, CL2 described their immediate emotional response to seeing the work, saying of the yeast: "They've been changed. They're designed. And for whatever reason, the fact that they were designed was a little unsettling." Several participants described the need for a critical lens on science, technology. For example, when asked about the relationship between DNA and identity, Mus5 emphasized, "That [question] has a lot of implications, you know." Participants offered comments regarding how macrolevel social, political, and economic issues might affect technology of the future. While CL6 highlighted the potential for bioart to subvert imperialist interpretations and uses of science, CL3 highlighted how bioart could stabilize hegemonic paradigms: "My vision as a marketer would be, as the moon landing is to space exploration, so bioart could be to, like, actual scientific progress. If this is the sort of thing that gets people interested, that gets funding, then that could be something big companies find really useful." In conversations following the artist talk, other audience members discussed with the artists patenting poetry-infused wine and potential markets for it. Thus, the artwork and events engaged people with diverse and sometimes conflicting values and beliefs.

Spatial design requires careful attention to promote inclusive dialogue. Mus4 described their desire for more room to maneuver: "I wanted to look at the back of it, cause there's something on the back of a wine bottle that I couldn't even read- I didn't want to knock anything over." Digital technology was observed to powerfully influence physical engagement. In comparison with sites 1 and 2, audiences at site 3, when entering as a group, filed into the back of the room, facing the smart screen–a less socially-oriented form of attention. When entering individually, they were observed to stand in front of the wine bottle facing the screen for a period of time or to walk around quickly crossing behind the wine (acknowledging the presence of the screen by not walking in front of it) before walking around the center back to the door.

4.4 Distributed Expertise

Building on empowered critique, *distributed expertise* describes audience members' experiences of engaging with the artwork through one or more areas of knowledge or personal experience. In this way, *Raaz* supports a distribution of expertise, across which people with diverse backgrounds may find ways to engage and contribute. In this section, we develop an account of how the experience of facilitated distributed expertise that *Raaz* presents may support individuals and communities in staying with uncertainty and facing difficulties by connecting with their areas of expertise and trusting others will do the same.

Many participants were struck by the novelty of the multimedia bioart installation and the experience of diving into the unknown. For example, CL7 shared, "I was talking to my partner, and I was like, 'Oh!' like, 'I'm going to go to this bioart thing.' And she's like, 'What the hell is bioart?'" Similarly, IT5 emphasized the importance of attending the talk before seeing the art, sharing "I think if I'd just gone in there, I would have been like, 'What the heck is this?'" Describing why they chose to try agar art, CL2 described enjoyment related to novelty and hands-on experience with tactile media: "I'm not particularly good [at art], I just love it. I love doing things. I love manipulating materials. It felt sensory. I like the idea of dealing with something sticky." Describing their experience working with microscopic, pigmented bacteria and yeast, CL9 (a painter) described drawing on agar as, "Really interesting because you don't know what the outcome is going to be, right? It's like you can have a plan going into it, but then you have no control over it, basically. Right? You have limited control because it's going to grow into something."

Participants described engaging with the form and content of *Raaz* from their point of expertise. For example, CL8 described the information theory aspect of *Raaz* as one of their main ways into engaging: "I have a computer science background so hearing how the poem is translated into a binary format which is then translated into a different medium, it feels very familiar." Mus4 reflected on what interested them about the biological aspects of the work: "I've done bio before, so it was interesting to see imaging that wasn't, like, the traditional- not boring, but [laughs]." Participants also described how bioart could enable engagement with bodies of knowledge despite little or no training. Painting on agar in the wet lab, CL9 explained: "It doesn't even matter if you're knowledge about biology. That's what I like about this because I'm not- I still get to see this and experience it, but I don't necessarily have to have a background in it or know anything about it." Other participants described the necessity of supportive information in their ability to engage with the work. For example, CL3 described the audio components of *Raaz* as "incomprehensible," but, "cool having heard

the process and hearing the audio and after that." Mus6 shared: "I really want to understand how it is [made] and not just an artistic point of view. I really appreciate the detail that was shared during the presentation." For IT4, transdisciplinary scaffolding led to an appreciation beyond "more than just a fun science project." They explained: "hearing a little bit about people, the creation of the wine and the sound and the process of everything, as well as the underpinning of history and culture and the research and the deeper meaning to a lot of the words. And even the wine itself has a deeper meaning that made it very different. It made it a lot more special, and I feel like, you know, I understood what was happening in there."

As expertise is distributed, so is its inverse; and participants also voiced tentative understandings and uncertainties about DNA and gene editing. CL7, who missed the presentation, engaged with the notion of consequences and responsibility in biotechnology through their understanding of the synthetic biology process employed by the artist in dialogue with the interviewer (who did not describe the scientific process, but encouraged the participant to continue thinking):

> CL7: Is it just, I mean, it did actually alter the DNA of the yeast, like fully? And then this is a totally different yeast than could ever exist and it has special functions that make it also good for this wine? Is that kind of the function of it?
> Interviewer: Yeah. Yeah.
> CL7: So the different poems encode, like make the yeast do a different thing? Like if I encoded, like a rock song, would it be more destructive or something?

Participants considered that these challenging yet important questions may not have a single answer. For example, Mus6 said, "[The artist] wants us to think, I think." In response to a survey item asking what the participant will continue to think about, IT8 wrote, "I'm not sure now. But if we think in practical sense, what will be the impact of *Raaz* on improving human nature on earth?" This comment, from a participant at site 3 (the HCI research center), reveals a critical engagement with art and technology.

In some cases, participants described interest in exploring similar projects, despite their inexperience with art and/or biology. For example, in a survey question about this, CL6, who is not an artist, wrote, "I could imagine a project around health, STIs [i.e., sexually transmitted infections], and microbiology. I'm a public health RN [i.e., nurse]." IT7 wrote, "The process lasted over 3 years. I will like to optimize the process," and "I will do well to increase the sound quality by improving on sound processing." Another participant, an HCI student, suggested that interviewers should be asking more HCI-oriented questions. Interestingly, we saw these comments more prominent from participants at site 3 (HCI research center). While embryonic, such perspectives would comprise valid contributions, as active engagement may or may not be through "art." By allowing for diverse areas of familiarity to engage with the work, bioart may distribute the burden of uncertainty across a community, possibly accounting for many participants' willingness to engage with aspects of the work they were less familiar with.

In contrast, the project's existence at the intersection of art, science, and technology was not easily received by all participants. CL2, who has a background in music, did not at the time anticipate applying their experience to a transdisciplinary art project, writing, "I don't have a strong bio background or art background " In interviews, most (though not all) participants expressed uncertainty as to whether they could apply their knowledge and skills to an artistic project. As IT6 put it, "At the moment, there's nothing in my mind that I can, you know, put in a sentence." Similarly, some participants described difficulty discussing the work, occasionally describing it as "above my head" (Mus3). IT6 described the artist having "the ego and desire to integrate art into his work" as "a really cool thing," however, not something they themselves could imagine doing.

4.5 Revealed Dynamics

Information about host locations and communities (i.e., sites 1-3) that may not ordinarily be directly encountered or noticed comprises *revealed dynamics*. Aspects of revealed dynamics are evident in changes to the artwork and artist talks, as well as in patterns observed among audience participants. In this final section, we draw on our observations to outline audience response to the format and configuration of each event and show how revealed dynamics shaped and were shaped by encounters with *Raaz*.

Audience members appeared interested and engaged during the artist talk given at the start of each event. With few exceptions (e.g., the event coordinator), people did not use mobile devices or laptop computers during the talk. On only one occasion did we observe someone use their phone to photograph the artwork. We observed attendees refer to the handout that included artistic and scientific information about *Raaz*, spend time with each element of the installation, and converse with each other, the artists, and the researchers.

Site 1 supported more audience conversation in the installation space itself, compared with other sites. This may be because the lighting did not separate the installation space from other spaces the way it did at site 2 and 3, a wider threshold without a door separated the installation space from the refreshments and presentation space, there was more room to gather in small groups, and the sound was less focused (and less audible). The agar art workshop facilitated conversation among attendees, most who came alone or with one other person. Participants described the agar activity as "relaxing." Approximately 5 adolescents who had been at the lab for another reason stayed for the presentation and agar art workshop. They did not engage with the installation, spending most of their time in the wet lab. At this event, the installation may not have appealed to a young audience. The agar art activity, refreshments, and comfortable seating supported conducting interviews, and we interviewed most adult attendees.

Site 2 attracted more audience members with formal art or music education, which is reflected in the interviews and observations. Site 2 encouraged greater engagement with the audio installation, which was fine-tuned. Audience members at site 2 mentioned shortcomings of the space, despite it being more supportive of the audio elements of the artwork compared with sites 1 and 3. As part of a larger event, site 2 saw a high volume of audience members both attending the talk and visiting the installation. The event attracted many art and music students, who get class credit for attending

events. We met professors from a variety of disciplines and from other universities. A handful of adolescents attended with their parents, and we observed them interacting with one another in the installation space. One participant (a professor) told us their adolescent son had said of the installation, simply, "It was very spiritual." Compared with the number of attendees, we conducted few interviews at site 2 due to the volume of people, limited space, and the amount of time audience members wanted to spend at the installation and broader festival.

The installation at site 3 was set up by researchers and artists during the day, attracting the curiosity of students working in nearby labs. Several students attended the talk or completed a questionnaire but left before we could interview them. The student and faculty attendees were generally amenable to being interviewed, as it is a typical research method in the department. Compared with site 1 and site 2, site 3 had very dramatic lighting, which one participant likened to a rave. The light and sound emanating from the lab's open door drew many students. Those who came following the talk tended to gather around the illuminated smart screen, which became a front side in the installation, previously oriented around the wine bottle at the center. Compared with site 1 and even site 2 (which was quieter than site 1), attendees at site 3 took on a reverent attitude in the installation room, shown by silence and prolonged attention to the screen and the wine bottle. We observed audience members questioning whether elements of the respective spaces incorporated into the installation (e.g., the chaotic sound at site 1 and the motion-capture system and treadmill at site 3) were intentional, highlighting the constructed boundaries of meaning with which transdisciplinary community engagement might play.

5 DISCUSSION

Human-computer interaction researchers and practitioners have long been interested in ways of thinking and doing that transcend arbitrary barriers to knowledge and experience. Through our work, we observe the similarities between two prominent approaches to transcendence in HCI: transdisciplinarity and community engagement. By bringing these two modalities of HCI research and practice into conversation and introducing synergies, we offer new ways of understanding and practicing both, as well as a third, combined modality characterized by liminal experience.

Transdisciplinary research and education in HCI hinges on the identification of an issue of shared interest or concern and the application of a wide (or limitless) set of disciplinary approaches to understanding and working on the issue, with the effect of involving diverse perspectives and producing more broadly meaningful work [12], often prioritizing "problem setting" over problem solving [13]. Bioart has been identified as an inherently transdisciplinary mode of working, where the content of the artwork and the desire for expression become the shared concern [44]. This modality and its potential to involve diverse collaborators is further enhanced by the need of many bioartists to turn to DIY and community science in order to access needed tools, materials, knowledge, and skills [7, 44, 59].

As described at the beginning of this paper, community engagement can serve a variety of purposes and is priority of disciplines ranging from health, to education, to business. While our methodology is concerned with culture and experience, it differs from methodologies such as traditional use of cultural probes in that it investigates collective rather than individual experience and eschews expectation of design and use. Within HCI, CE has become associated with participatory design and through this connection has come to be understood as a means of developing publics, where people can learn from each other, find areas of agreement or compromise, and work together to prioritize and define possible actions [30, 61, 62].

Both transdisciplary and community-engaged modes of HCI research and practice involve bringing people and communities with diverse experiences and skills together, and we now unpack how each may change upon their convergence in two areas, (1) making community and (2) revealing issues of concern. Finally, we discuss the role and potential of *liminality*, a transformational and transitory state that occurs in the space between two stable states [101], as a space where transdisciplinary community engagement can support uncertainty and change, and why this matters.

5.1 Making Community

Human-centered computing projects with a goal of community engagement often begin with a defined community in mind, with "community" routinely defined anew for specific situations, and delineated through factors such as shared geography, identity, and/or interest and practice [31]. The audiences of each event we studied can be described as more-or-less discrete communities, in particular in the realm of shared interest and practice. While these are fairly clear-cut at sites 2 and 3, which engaged university-based communities, the shared interest and practice of the audience at site 1 could be described as a community with the shared interest in and practice of attending local arts and community events. Given that we observed participants interacting with one another and with the artists at each site (though not equally) and were willing and able to experience the unknown and reflect on deeply personal issues during interviews with researchers, we believe that bioart projects, such as *Raaz* can facilitate the foundational CE work of finding and building community, which must precede or coincide with the work of developing publics.

As a means of instigating CE, we observed that our events attracted people who knew little to nothing about bioart in advance and who had little in common at a personal level (even at sites where most attendees shared a professional background). Thus, bioart can expand our notion of CE from *activity that engages people who have something in common*, to *activity that engages people who* could *have something in common*. Echoing the theme *performative reflection*, the situation of bioart as a form of making, we observe its potential for making community. This work, while similar to the articulation work of CE that Corbett and Le Dantec [22] identify in building relationships, precedes it by enabling relationship formation in the first place. As one participant put it, events such as these provide the opportunity for people "at least learn how to make friends." While participants at sites 2 and 3 did interact within and outside the installation space, they also suggested ways the event could be more social and interactive, which the hands-on component of the event at BUGSS (site 1) facilitated (Figure 5).

Placing bioart in emerging communities can expand opportunities for transdiciplinary knowledge generation by involving diverse individuals to enter into dialogue from their point of reference, thereby expanding the possibilities for collaboration and further

Figure 5: Attendees make agar art at site 1 while participating in research activities (front right). They can be seen working individually, observing others, and speaking with the Executive Director of BUGSS, who demonstrates a lab technique (back right).

community building. Our study of audience experience of *Raaz* teases apart and magnifies possible mechanisms through which community might be made: a sense of *vital authenticity* may inspire vulnerability and connection while *empowered critique* and *distributed expertise* further promote inclusion and collaboration by relying on diverse and decentralized contribution to both art making and audience meaning making.

5.2 Revealing Issues of Concern

Identifying issues of shared concern is a challenging task for CE, in particular because community members may have vastly different experiences, resources, and attachments, which together form their concerns [30, 61]. While not a replacement for the important work of participatory deliberation and political action [6, 22, 39, 61], art can support these and offers a window into shared and conflicting values and priorities which, if known to the community, could support additional CE work as issues and needs for action arise.

Among *Raaz* audiences, we observe a plethora specific issues of potentially shared concern. While the perhaps most fundamental content of the work–the centrality and universality of love–is repeated across language, medium, and form, reflections on this level of content was not explicitly highlighted by the majority of participants. This may be an artifact of the way art "works" on audiences over time or of our data generation methods, which tended to privilege use of conversational language over forms of expression which may better communicate aesthetic experiences of love and the ineffable more broadly [15]. However, our findings suggest that the agency of artists to choose the form and content of their work suggests that, as a tool for community engagement, art can seed values and concerns for reflection and discussion.

We also observe that performativity (in the Austinian sense [8]) is a key aspect of bioart, insofar as the living media itself often *is* "the message" (as in "the medium is the message" [73]) in a more direct (identical) way than digital media [76]. Similarly, as a means of CE, the events were performative in that audiences became directly involved in reflection and questioning related to the issues the *Raaz* elevates. This could potentially prepare audience members for future individual and collective reflection and questioning as public issues are identified through processes of making community and identification of *revealed dynamics*.

Previous work has identified audience questioning the materiality of bioart as a significant outcome [97], in particular as simple questions such as "Can we drink the wine?" are, in the case of *Raaz*, loaded with concerns related to biosafety and artistic value, and ultimately the morality and authority the work itself questions. Our analysis shows that bioart can inspire questioning extended to more individually and collectively personal concerns. The significance of vitality and change, for example, indicates possible avenues of future CE and transdisciplinary research that might explore relationships between the living world, science, technology, and design, pointing toward future contributions in sustainable HCI [56]. Transdisciplinary art and HCI research are in turn enhanced by community bioart events through ongoing connection to audiences that raise new issues to serve as the center of collaborative research and creativity.

5.3 Engaging Transformation and Transition

One way to conceptualize the relationship between transdisciplinary modes of research and creativity and community engagement and their confluence involves the notion of *liminality*, a transformational and transitory state that occurs in the space between two stable states [101]. Our study demonstrates how groups of people who have–or could have–something in common experience bioart as a liminal space through exposure to new knowledge, ways of knowing, and vital sensory experience. We posit that *Raaz* acts as a liminal space where traditional and habitual ways of being are suspended. After the event, the context comes back together, but not the same way it was before. There are new and different relationships, new and different possibilities.

Current theoretical conceptions of bioart can be understood as experimenting and interrogating within liminal space. For example, many bioartists and critics hold the view that bioart is a powerful and productive criticism tool of the contemporary innovation ecology and particularly the biotechnology industry [1, 4, 5]. Robert Mitchell builds on this to describe on how bioart can act as a means to create new folds (i.e., intersections) between institutions (e.g., universities, artist studios, biology labs, etc.) by acting as a *line of flight* [76]. In this context, a line of flight is a mechanism to temporarily disrupt, subvert, and destabilize (i.e., deterritorialize) ingrained ways of being and knowing to create an opportunity for their rearrangement into new constellations and integration with new areas (i.e., reterritorialize). Specifically, Mitchell draws on work by Deleuze and Guattari [26, 27] to show how bioart can disrupt and reorganize existing disciplinary structures and mechanisms to create new relationships.

Computing and interaction design researchers have investigated the liminality of physical and digital experience, for example, through augmented reality [64] and social media [41], as well as through a postphenomenological (e.g., [104]) perspective where the technology is integral to life experience [41, 51]. The liminal has been identified previously in audience experience of art [23] and explicitly highlighted by art using the tools of HCI [70]. Liminality is also a generative concept in transformational education [35, 88].

The potential for transdisciplinary CE to create a space of liminality may have important implications for HCI research interested in designing to support exploration of uncertainty and change, in particular given its potential for including and supporting diverse experiences and perspectives. Soden et al. outline four HCI responses to uncertainly, of which they find the desire for "taming and disciplining" the most common [95]. Our findings contain an echo of this reaction, but the other three modes of uncertainty response they identify–viewing uncertainty as generative, political, and affective–are more prominent in our analysis, where they are notably collaborative, critical, and socially-oriented.

5.4 Vitality and Liminality in HCI

In this paper, we look closely at a specific example of bioart installation as a transdiciplinary means of community engagement, and describe both how it can happen and what it can do from the perspective of audiences with diverse disciplinary backgrounds. This naturally includes interaction with living organisms and organic matter. We anticipate that our analysis may provoke further investigation of living media systems and bio-HCI, and that our findings might inspire design research in these fields. Involving biology and the living world in design and art research has the potential to reach and engage a wide range of individuals and communities, and can engage amateur and non-expert perspectives with the support of practices such as DIYbio and community labs. Furthermore, where interaction with living media might productively connect users with social and environmental information [19, 46], exploring this information in a community setting can facilitate engagement with significant personal and local issues [105].

Audience members also reported critical engagement with ideas and materials that may be explored toward a transdisciplinary community-engaged HCI that do not necessitate the involvement of living media or biology. Extending our findings, we present lessons learned that might be explored further in other contexts and beyond bioart. First, we found presenting technology embodied in an art installation invited open-ended engagement and discussion among audience members. Second, we found that the translation and repetition of a central concept in multiple "languages" opened up new ways of thinking about these media. Third, we found including multimodal explanation and dialogue through artist-scientist talks and discussion important for supporting audience engagement. Finally, we found investigating how specific communities respond to transdisciplinary, arts-based interventions productive as a means of advancing participatory research and design.

We envision transdisciplinary art- and community-based gatherings with possibilities for making community and revealing concerns, such as we examine in this paper, could be used in tandem with other HCI research and creative activities, such as those involving artificial intelligence, virtual and augmented reality, interactive wearables, and others, endeavoring to motivate and facilitate not only public understanding and discussion of the role of technology in society, but also *empower critique* and participation in the liminal spaces inherent both in making (as bioart demonstrates) and in unmaking [89, 90].

6 LIMITATIONS

Our study has several limitations that can be addressed in future research. First, we focused on the immediate responses of audience members and did not do follow-up interviews or surveys to see how long these impressions last. Second, although the researchers performing data generation activities were introduced to audiences as distinct from the artistic team, we expect participants may have felt reluctant to share neutral or negative responses. Interviews elicited examples of uncomfortable or negative experiences regarding the work's content, but less so the work's form or the design of the events. The questionnaire may have served as a channel for critical feedback. Third, the characteristics of *Raaz* impact our research outcomes. By virtue of being an artwork, *Raaz* engages with specific cultural, scientific, and technological questions and processes, a quality that undoubtedly impacts audience experiences and responses. A future study can investigate how the particulars of audience experience can transfer to engagement with other types of bioart and biodesign artifacts and experiences. As a tool for producing liminality in different contexts, *Raaz* could induce what people might experience as desired or undesired transformations, calling for more work on responding to diverse experiences of uncertainty in transdisciplinary community engagement. Finally, in the current study, while the audience participated in experiencing bioart, and in the case of the first site, a hands-on bioart activity, they did not directly work on creating their own bioart projects. In the future, we would like to investigate how to create participatory mechanisms to enable non-expert community members to create and experience their own bioart and understand the impact of participation.

7 CONCLUSION

The empirical fieldwork we report in this paper describes how three bioart event audiences interacted with the art, each other, artists, and researchers and their views on their experience of the artwork and reflections on related issues. We describe five aspects of how this unfolded and took shape, outlining how bioart works as a means of community engagement through (1) vital authenticity, (2) performative reflection, (3) empowered critique, (4) distributed expertise, and (5) revealed dynamics. We found that the transdisciplinarity of bioart can converge with practices of community engagement, extending knowledge about making community and revealing issues of concern that can enhance the practice of both. Finally, we discuss the role and potential of *liminality* as a mechanism through which transdisciplinary community engagement can support uncertainty and change. This may contribute to the development of more inclusive and participatory research engagements and ultimately (un)design. This work also represents initial work to explore community engagement on the subject of emerging science and technology.

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A DATA GENERATION GUIDES

A.1 Observation Guide

1. Who is present? [attendees, artists and collaborators, researchers]
2. Sequence and duration of interaction [consider various components of the artwork and space]
3. How do people take up or move around in space?
4. How do people engage with one another?
5. Do people talk? What kinds of things do they say?
6. How do people engage with components of the artwork? [visual, aural, tactile, etc.]
7. How do people use their personal digital devices?
8. What is the affective tone of the space?

A.2 Interview Guide

1. Have you heard about or seen *Raaz* before?

   (a) [If yes] What did you know about it before today?
2. Did the artist talk influence your experience of the installation?
   (a) [If yes] How?
3. Thinking about this event and about *Raaz*, complete this sentence: "I didn't know…"
4. Again, thinking about this event and about *Raaz*, complete this sentence: "The artwork reminded me of…"
4. How would you describe connections between DNA and identity?
6. What do you hope the *Raaz* artists will do next with their work?
7. [At site 3] Are you a teacher or instructor, or primarily a student?
   (a) [If teacher] As a teacher, what's the most important thing for students to learn?
   (b) [If student] As a student, what's the most important for you to learn while you are here?
8. [At site 3] Are you involved in conducting or assisting with research?
   (a) [If yes] Can you summarize your research in a few sentences?
   (b) [If yes] What connections can you imagine or describe between your research and art of any kind?
9. Is there anything we should have asked you that we didn't?

A.3 Questionnaire

1. How did you find out about this event?
   □ Mass email invitation
   □ Personal invitation from colleague or friend
   □ Other (describe)
2. About how often do you attend arts events? (including both online and in person)
   □ Once a year or less
   □ A few times a year
   □ Monthly
   □ Weekly or more
3. About how often do you attend science events? (including both online and in person)
   □ Once a year or less
   □ A few times a year
   □ Monthly
   □ Weekly or more
4. What is your field of study or major?
5. What is your occupation/profession?
6. "Bioart" is art that includes living organisms or uses biotechnology techniques. *Raaz* is an example of bioart. Before this event, what was your experience with bioart?
   □ Not familiar
   □ Knew a little
   □ Knew a lot
7. Did you attend the artist talk before visiting the *Raaz* installation?
   □ Yes
   □ No
8. Can you imagine using your skills, resources, or expertise to contribute to a (bio)art project? If yes, in what ways would you contribute? If no, why not?
9. If you continue thinking about one or two aspects of *Raaz* in the coming days, what might they be?
10. Do you have any suggestions for what to change or include in future (bio)art events?