

Ephemerides: A Microtonal Feedback Instrument Based On Transgender Voice Training Technique

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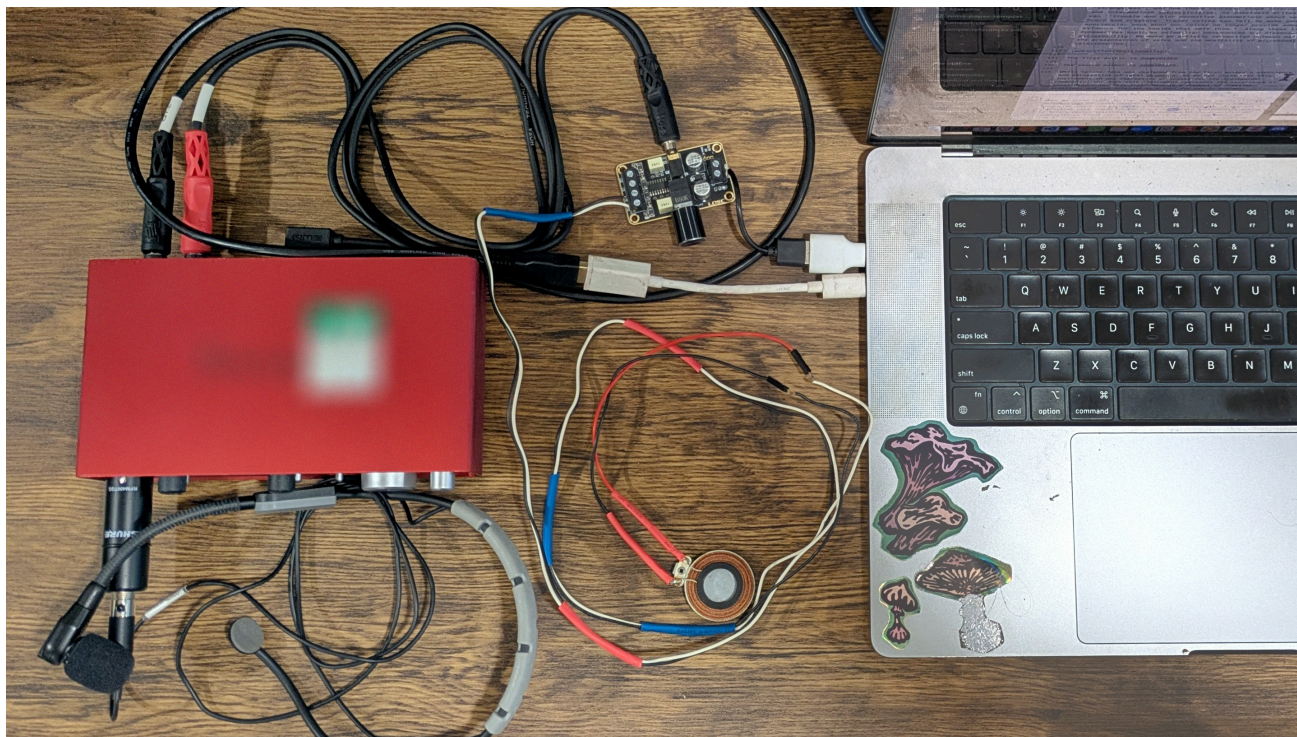


Figure 1: Connected components of Ephemerides: handheld voice coil transducer, headset wired microphone, laptop running a Max patch, small amplifier board, and audio interface.

Abstract

Digital musical instruments afford new opportunities in exploring experiences of ‘otherness’, like defamiliarisation or gender dysphoria, through more-than-human design. Transgender voice training is an emerging practice assisting in the modification of voice presentation for trans people, often grappling with this sense of otherness. We present Ephemerides, a microtonal feedback instrument based on transgender voice training technique as a product of practice-based research. This instrument does not require the use of vocal cords; the musician manipulates resonances in the vocal tract to change pitch with the help of audio feedback. Concerning this unusual way of producing voice, the instrument questions what constitutes intention, agency, and gender in singing. Designed with the intention of unpacking social stigma surrounding gender exploration in voice, we argue for a stronger role of digital instruments in challenging dominant

narratives surrounding marginalised bodies through queering cultural contexts.

Keywords

microtonality, autobiographical design, voice, digital musical instruments

1 Introduction

Embodied senses of discomfort and estrangement have been explored and expressed in both designing and performing with digital musical instruments (DMIs). Musician-instrument dynamics like ‘disfluency’ [5], noisy biofeedback [12], or intense physical exertion [36, 49] demonstrate musicality with digital instruments with clear transparency of body exertions. This strain of design research views strange and difficult experiences as part of the human experience, valuable in communicating a deeper sense of bodily processes through music. Beyond artistic value, negotiations between the musician and instrument shape musical practice and the musician’s body [36].

This paper describes designing and performing a vocal DMI, Ephemerides, with vocal dysphoria. We use ‘designing with’ as distinct from ‘designing for’ to express how this specific bodily



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distress affected designing decisions and resulting musical technique. Vocal dysphoria is a kind of gender dysphoria that refers specifically to the production and presentation of voice that is incongruent with an individual's gender or sexuality. Described by Povenelli et. al. as an "emotional and psychological distress" [43], this bodily phenomenon appears in a variety of contexts, including singing [8], in-person communication [16], and virtual meetings [43]. Holmberg et al. characterise vocal dysphoria from a clinical perspective into three major themes: an incongruent voice that dictates social interactions, a voice that has been culturally impressed from before transition, and a desired voice that is "out of reach" [26]. These themes generally refer to a disconnect between an individual's identity and their ability to express that identity through voice. Our research focuses specifically on vocal dysphoria as it relates to the first author's lived experience as a transfeminine person.

Ephemerides is a feedback instrument that employs transgender voice training technique, through the manipulation of vocal resonance. Gender-based voice training is an emerging practice, taking influence from both musical technique and speech therapy [16]. There is a small amount of research with transgender voice training technique [16], and little research that we could find of trans voice outside of qualitative personal accounts. Apart from pitch and inflection, vocal resonance is one of the primary focuses of voice training as it is one of the biggest audible factors in a testosterone puberty. Vocal resonance is a quality of human voice determined by the shape and size of the vocal tract, distinct from the pitch of the voice. Acoustically, vocal resonance pertains to the frequency response of the filter formed by the vocal tract. Because the quality of vocal resonance is changed significantly by a testosterone puberty and affects the gendered perception of bodies, it contributes to the secondary sex characteristic of voice [7]. Manipulating vocal resonance requires a variety of muscle engagements and variations that a vocalist may or may not be used to, such as fine adjustment of the larynx, pharynx, lips, and nose (Figure 2) [7]. Many transfeminine people who go through voice training therapy face difficulty with manipulating vocal resonance, as it is a quality more abstract than the fundamental pitch.

Beyond the biological and technical understandings of gender in voice, we explore artistic themes of 'otherness' and 'strangeness', and how these concepts shape internal, external, and intermediate perceptions. As Anastasia writes, trans voice can "trouble and blur normative assumptions about sex and gender, human and creature. Trans* voices can fail to make sense in spectacular ways when our voices no longer provide adequate evidence for the bodies that emit them" [2].

Ephemerides is a result of distancing ourselves from gendered norms in voice, incorporating microtonality to explore and express musical otherness, disrupting the physical process of using the vocal folds to produce voice, and using experimental music culture to access performance of this voice. Microtonality in and of itself does not express otherness, but the first author makes an artistic connection with arranging unusual chords, intervals, and interactions as an exploration of musical otherness. Along these lines, Ephemerides explores unfamiliar consonances and dissonances with microtonality. Apart from gender identities (like man or woman) or categories (like non-binary identities), other gendered qualities have a potential to be expressed through a framing of dysphoria and affirmation [56].

In addition to contributing the instrument Ephemerides, which introduces transgender voice training technique in a vocal DMI,

Attributions to Vocal Resonance

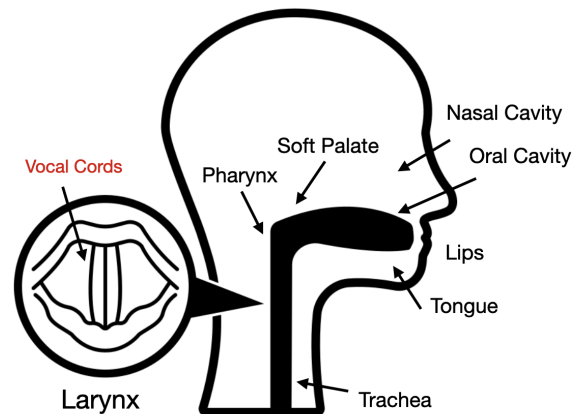


Figure 2: Vocal resonance in the context of voice training is often broken down into laryngeal resonance in the throat, oral resonance, and nasality. Each of these resonances affect voice quality. Vocal cords do not affect resonance, but are labeled in red to show where they are.

this paper draws on a design process with vocal dysphoria to make provocations surrounding ideas in access and gendered voice in DMIs. We describe how the process of estrangement has reshaped our original intentions of trying to understand gender in voice through technology.

1.1 Positionality

This paper is led by the first author, connecting her practice of voice training with critical theory and design. The second author has contributed to the framing of the work and advised on certain design aspects of Ephemerides.

The first author is a trans woman who experiences vocal dysphoria, even after years of gender-based voice training, and contextually identifies with the term disabled; she is autistic and has ADHD.

While Ephemerides was designed from the first author's experience and perspective of vocal dysphoria, we do not claim that this instrument in any way represents or speaks for the transgender community, nor does this instrument represent the experience of vocal dysphoria. This instrument is a product of creative practice, and not intended as a tool for use in therapy.

2 Background and Related Work

Concerning vocal dysphoria, and including transgender perspectives in design, what we think needs further exploration is moving beyond clinical perspectives. Regis et al. aim for "a more inclusive and broad perspective that prioritizes the varied and subjective experiences of trans and non-binary individuals, aiming to inform design solutions that are attuned to the diversity and complexity of lived realities" [48]. We look to creative practices that see the phenomena like dysphoria as something to work with for creative and design practices [56].

Ephemerides was largely influenced by concepts in soma design and incorporated a specific method called *Noticing* [33]. Noticing can incorporate a variety of methods and perspectives

to uncover more tacit expressions and interactions that are not easily described [41]. This method, under the larger soma design umbrella, provided a way to begin articulating a delicate and nuanced first-person perspective into language. The soma design framework comes from somaesthetics, a philosophy that human intelligence is enacted through interaction and therefore a relevant lens for interaction design [28]. Soma design, by definition, is a first-person design method to elaborate and delineate kinaesthetic and somaesthetic knowledges, but expands into more-than-human territories [53, 57]. For the purposes of this paper, use of the term more-than-human is limited to the scope of instrument and musician, within the context of a music culture. This perspective changes the view of bodies from generally self-contained entities towards dynamic and complex entanglements of humans, technologies, and environments [27]. Combining the more-than-human perspective with soma design can be a lens for discovering the subjective relationship of the body with and through technology and the assembled body that emerges in relation to technology [61].

2.1 Related Vocal DMIs

2.1.1 More-Than-Human Conceptions. Recent findings in DMI research have shown vocal instruments as a meaningful avenue of using digital technology to reconstruct human agency, design with the body, and express identity. Cotton et al. prototype a vocal apparatus that incorporates features of the breath with a reactive corset [12]. Reed et al. developed the Singing Knit, an e-textile wearable for laryngeal muscle interaction [47]. Reed later through autoethnography unpacks notions of control over voice in extensive work with the laryngeal muscles, showing how DMIs can have a role in interrupting, disrupting, and modifying how voice is produced, felt, and perceived [45].

2.1.2 Soma Design. Soma design is directly applicable towards musical instrument design to account for the bodily experience of the musician [35], describing unfamiliar human-machine dynamics [32], or sensitising the designer more deeply with artistic practices [3]. The Body Electric [12] and Bones [18] use soma design methodologies to connect breath and other bodily expressions meaningfully into vocal instrument design. Friere and Reed describe this practice as “Body Lutherie”, viewing the body as a collaborator and welcoming its “noisy, uncontrollable influence” [18].

2.2 Social Access and DMIs

Trans embodiment is rarely a question of access in relation to digital musical instruments, however, vocal dysphoria can be a barrier in the context of vocal practice. Carlson, in the context of choir education, warns that when a choral ensemble necessitates gendered elements, it “may cause [gender diverse] singers to stop singing in choir or to stop singing altogether” [8]. Their recommendations, in a survey of trans and gender non-conforming singing, is to train educators in using gender-inclusive language, understanding the effects of testosterone for transmasculine people, and advocating for gender-diverse expression [8].

Within NIME discourse, Accessible Digital Musical Instrument (ADMI) design addresses social access for disabled musicians. Harrison cites *attitudinal barriers* as “prejudice, stigma and discrimination against disabled people”, most often through the way that an instrument is played [25]. Thorn et al. challenge “neurotypical models of intention and agency” with a strategy called “neurodiverse sensemaking” in which computational thinking

becomes “deeply embodied, multi-sensory, and relational” [55]. They move from the idea of making instruments for therapy contexts and think more broadly about differences in bodies, like learning differences, applies towards designing musical instruments.

There are several examples of NIME’s that broaden social access. Dalglish’s Chimera is a result of diligent prototyping, exploration, and autoethnography documenting his design process as a one-handed musician [14]. Zayas-Garin and McPherson offer dialogic design as a co-design method for ADMIs, including “the designer/researcher’s influence, expressed both as domain-specific expertise and preexisting artefacts”, and the subjective knowledge of disabled people [60]. Iványi et. al. use participatory workshopping with children with autism to develop a tablet music application in conversation with both the children and their educators [29]. In these examples researchers demonstrate their process of navigating disability, working in dialogue with people with disabilities, or working in community settings. These examples are far from exhaustive, but show different approaches in breaking down attitudinal barriers.

2.3 Digital Microtonal Interfaces

Approaching microtonality through digital instruments provides a computationally efficient method of generating complex pitch relationships, and quickly hearing how those relationships sound through digital synthesis. Apart from non-Western scales and tunings, Ephemerides is concerned with Western microtonality. However, Western microtonality often remains theoretically dense, with its composers often organising pitch space with lattices, 3D diagrams, or well-populated charts¹. In response to this, Dalmazzo et. al. created an application for exploring microtonal music with a 53-TET system [15]. This system aids composers with a tool for exploring harmonic relationships, modal interchanges, and other important factors in composing in microtonality. Christou approaches microtonality with a game-like interface, making Just Intonation systems more intuitive to conceptualise and perform with [11]. Magnussen introduced Threnoscope, a system within SuperCollider, for crafting live-coded droning microtonal compositions [34]. Systems like these allow musicians to think through microtonal composition in ways other than traditional Western notations.

Our strategy for making microtonality more intuitive for musicians, composers, and designers is through vocalisation and being able to imagine, hear, and think microtonally with voice. Guidi et. al., through the example of playing microtones on a violin, found that auditory imagery affects what they call ‘performer fluency’ [23]. “We propose that a lack of auditory imagery constitutes a mental limitation rather than a technical constraint in the design process. Hence, the design lens should shift from a technology-focused view to include a more human-based perspective to address such a limitation” [23]. A few examples explore modifying physical instruments to play microtones more precisely, enabling auditory imagery through practice [10, 13]. With regard to voice, Reed et. al. note the importance of auditory imagery ability in the accuracy of tonal singing [46]. Therefore, a microtonal vocal interface should carefully consider the role of body, sensorimotor interfaces, and unique ways for approaching vocalisation.

¹https://en.xen.wiki/w/List_of_microtonal_software_plugins

3 Ephemerides Design

This section breaks down the practice-based design process into four parts: Prototype (3.1), Initial Design Qualities (3.2), Noticing (3.3) [33], and Performances (3.4). Ephemerides as an instrument is a research product [42], in that the prototype was inquiry driven, and our contribution is formulated by using the instrument as a tangible reference in a larger discourse.

The organisation of this section is outside of chronological order so that that we can prioritise the description of the instrument before describing how we arrived at the prototype. The prototype describes the current iteration of the instrument, which was constructed after the Initial Design Qualities and before Noticing and Performances. The Initial Design Qualities describes both design motivations and what design goals were adjusted as a result of making and conducting the Noticing exercises. The Noticing sections serves to explain how the instrument came to re-center the experience of dysphoria. Finally, the Performance sections outlines the ways in which we have presented Ephemerides with the public.

The primary driver in designing Ephemerides was practice-led methods [21]. This instrument leverages two of the first author's existing practices: programming in Max to work with microtonality, and gender-based vocal training that started 2 years prior. As this instrument was driven by combination of artistic and theoretical inquiry, audio recordings, video recordings, and written notes were taken throughout the process. After a prototype was reached, the soma design method Noticing [33] was utilised to gather a better qualitative sense of bodily experiences. The field notes were regular, writing twice a month from 30-60 minutes and once a week during the Noticing sessions. Voice recordings were much more sporadic and in-the-moment. Distributed through the design process, the three kinds of performances were explored after the prototype was built: a live concert setting, a few rehearsal sessions with an ambient electronic ensemble, and a two live-streamed development sessions on Twitch.

3.1 Prototype

Ephemerides consists of a Max patch, microphone, voice coil transducer, and the vocal tract (Figure 3). The signal from the Max patch plays through the voice coil transducer, which the musician then places firmly against their throat (Figure 5). The resonances of the throat and inside of mouth filter the signal from the transducer. The resonant frequencies are then picked up by the headset microphone, where the strongest resonance is reinforced by the feedback path. Automatic gain control in the form of a look-ahead limiter helps regulate the gain of the feedback path. This configuration is partly inspired by the Clarimate², which determines what note a clarinetist is playing by playing a chirp signal and then analysing the frequency response from within the instrument. Instead of determining which note a musician is sounding, however, all qualities of the interaction are preserved without MIDI note detection.

The oscillator bank is a musician-selected array of pitches that are all played at once through the transducer. These pitches could be a chord, chord extensions, or an entire scale. The musician 'selects' pitches from the oscillator bank by changing their vocal resonance, without the use of vocal cords. This is accomplished by manipulating the larynx, tongue, and soft palate, similar to techniques used in transgender voice training (Figure 2).

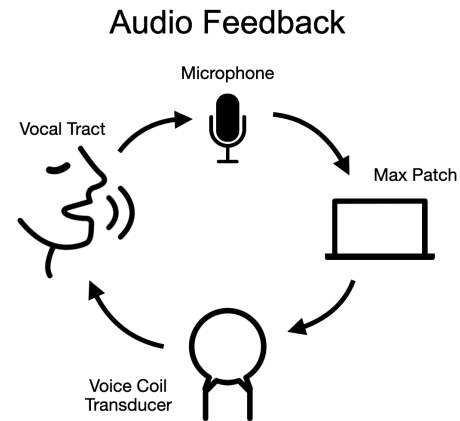


Figure 3: Ephemerides consists of a Max patch, microphone, voice coil transducer, and the vocal tract, with the audio signal path following the arrows as shown.

Reinforcing this phenomenon is a Constant-Q transform implemented through a series of bandpass filters [6]. The Constant Q Transform's frequencies are also determined by the selected pitches in the oscillator bank. Depending on the gain and Q-Value of this filter, the sensitivity and 'jumpiness' of the pitch can be finely tuned. This filtering has greater resolution in lower frequency bands than the Fast Fourier Transform (FFT), as the FFT separates the entire spectrum into linearly-spaced bins. A full block diagram of the Max patch is drawn in Figure 4.

Ephemerides only uses a microphone as a sensor, without detection of vowels, formant frequencies, or highest frequency peaks in the digital signal processing. In direct contrast to voice training apps that aim to 'detect' vocal resonance through formant analysis, the role of listening is passed on to the musician and the audience. Ephemerides uses pitch detection to set a reference pitch in order to build a microtonal scale, and a Constant-Q Transform to reinforce feedback behaviour, but it does not do any classification to understand anything about the musician or the pitches produced.

Ephemerides uses a microtonal algorithm to choose the frequencies for an oscillator bank. While a default setting might be a 12-tone equal temperament selection of notes (i.e. a 2:1 pitch ratio divided logarithmically in twelve equal ratios of $\sqrt[12]{2}$), the musician can redefine the frequencies to any set of ratios M/N , where $1 \leq M \leq 32$, $1 \leq N \leq 32$. The musician can further modify the spacing from logarithmic (like equal-temperament) to linear. For example, given the ratio $M = 8$ and a subdivision of $N = 3$, the patch would take the ratio and divide it by the number of steps, making the separator $(8*1)/3 = 8/3$ and the resulting values 1, 8/3, 16/3 and 24/3, which are multiples of 8/3. All ratios are calculated with respect to a specified reference frequency. A current limitation is that it cannot produce scales with uneven spacing between pitches, such as just intonation, Arabic or Indian scales, Indian Scales, etc.

As Ephemerides involves manipulating a group of muscles that are not commonly exercised in daily speech or vocal practice, there's a learning curve before the average musician or vocalist could produce a level of accuracy and versatility normally

²<https://clarimate.us/>

Max Patch Block Diagram

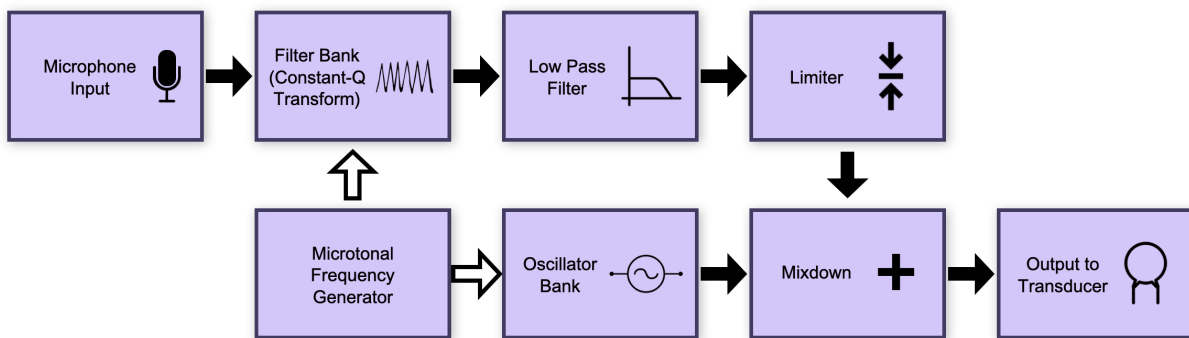


Figure 4: The block-based diagram shows control and audio flow from one part to another. The audio path is shown in black and control-rate signals are shown in white. The audio output from the transducer is then fed back into the input after traveling through the vocal tract.

expected from a musical instrument. It produces an effect of de-familiarisation of the voice, disrupting how voice is produced and how singing is performed [58]. Anyone with experience with experimental vocal technique, throat-singing, or gender vocal training is at an advantage when playing, and traditional techniques could be considered disadvantaged.

With this configuration we are in proximity to what Reed et al. describe as reconfiguring of the voice [45]. In using digital technology to create a vocal apparatus, we are redrawing the boundaries between the human body and an electrical system, audio production and signal representation, and intentionality and physicality [45]. Agency of pitch creation is distributed between both the device and the musician.

3.2 Initial Design Qualities

Embodying Microtonality. Our starting point was the first author’s pre-existing microtonal synthesis plugin. Like many other recent experiments with microtonality [11, 15], it came primarily from a motivation to explore alternative tunings in music through game-like interfaces, showing creativity in representing pitch relationships. We, however were looking to go beyond theorising about numbers and pitch relationships themselves, using design to better explore how these relationships sounded. Our intuition was that if these relationships could be felt through or limited by voice, the music made would have a deeper connection to auditory imagery and intuition.

Finding an Unheard Voice. Inspired by queer theory and the concept of the Otherwise [30], we theorised about potential applications of this theory in DMI design. The objective was to move beyond what Morrison and McPherson characterise as the reproduction of instrument paradigms, like the keyboard and step-sequencer as cultural entanglements with digital artefacts [38]. The Otherwise, by contrast, is characterised by the pursuit of the unknowable, or the inconceivable. We were curious how digital technology could find a different, alien, or monstrous singing voice that didn’t previously exist. One question that kept rising was a possibility for ‘modulation’ of gender expression, and whether or not an instrument could produce some kind of ‘sonic drag’.

Understanding Gender in Voice through Technology Our first technical explorations included vowel synthesis and formant analysis to connect signal processing with gendered characteristics. The idea was to connect spectral qualities of gender in voice to digital mapping parameters. After further reflection, the idea of detecting gender, even indirectly for the purposes of modulation, leads to a slippery slope in determining gender through machine listening [52]. Gender in voice cannot be wholly represented in or analysed from an audio file; it is fluid, dynamic, and culturally relative.

3.3 Noticing

As part of the design process, after completing the initial prototype, we used Noticing [33], a soma design method, as a way for the first author to better understand their vocal dysphoria. Noticing is a practice that involves connecting with a number of senses, contexts, and perspectives over time, and the methods vary widely depending on the subject. “Common for all methods of noticing is a first phase of sensory awareness and attuning and a second phase of articulating these sensations in language” [41]. Over four sessions, once a week during July 2025, and using the Methods for Noticing Workbook [33], we created an exercise without the instrument, to discover and elaborate in better detail what vocal dysphoria is and how it appears subjectively as a phenomenon. A recording of one of the sessions can be found in the supplemental material.

Background. We position vocal dysphoria as a felt sense [41], or embodied knowledge that’s difficult to explain or reproduce with language. By spending time with a particular sensation and choosing language to describe it, “we can uncover nuanced aspects in our experiential relationship with the environment that are difficult to access through mere observation or analysis” [41]. Modern voice training tools, while accounting for adaptability [1], personalisation [43], and modern signal processing techniques [31], have yet to explore soma-led techniques to qualitatively understand the nature of dysphoria.

Exercise. The exercise involved singing at a consistent pitch, slowing and varying resonance from high to low, or low to high.

Each session was ended with some freeform singing. The reflections from these sessions developed the relationship of vocal dysphoria with the design of the instrument. As *Ephemerides* does not involve vocal cords, these exercises were an attempt to contrast the playing of the instrument with resonance-based singing. See supplementary material for an example of one of the exercises (`excerpt_soma.wav`)

Reflections. A few reflections from the sessions are below:

I felt like dropping my voice to access kinds of throat singing. At first there's that twinge of dysphoria, what if someone hears me or perceives me, or worse, that I perceive myself as male again? But I slipped into it and the maleness became a bit decontextualised as I drone from resonance to resonance, and I could focus less on the gender-ness of the voice and more on the qualities and musicalities that emerge [Field Notes, 8th July]

Not to mention the strange urges and desires that I feel when exploring these areas, especially in the extremes. A lot of feminine voice training is about avoiding nasality, and found myself actively hitting a level of it just to see how it would sound and what it would feel like. If my speaking voice were to ever have that level of nasality I'd cringe so hard I'd fall out of my chair. It's one of those clocky features of transfeminine voice that comes from early on training and takes months or years to move away from. [Field Notes, 17th July]

These exercises bear strong resemblance to voice training exercises in how they are performed, but they are distinctly different in that they were not aimed at skill-building, but listening. By tuning into the internal thoughts and processes of their body through Noticing, the first author had a much better sense of what narratives drive the dysphoria and what creativity lies in being able to express it.

Further, noticing aspects of dysphoria while singing made clearer how *Ephemerides* seems to 'strip' normative aspects of gender from the singing voice. The pitches of *Ephemerides* do not match typical vocal ranges, and so it sounds like the 'singing' could be of any gender. This instrument is also restricted to sine waves and vocal filtering, abstracting many of the qualitative aspects of gender from voice that come from the vocal folds, similar to vocoding, pitch-shifting, and other audio effects.

3.4 Performance

As A Solo Performer. We co-organised a concert with other researchers at Piehouse Coop, a local music venue in London. The space created an alignment with the goals of our practice-led research and a potential audience for this instrument. The first author performed the instrument through improvisation, integrating spoken-word poetry in between vocal performances.

With a Collective Over 3 sessions, *Ephemerides* was presented to a collective of musicians and played alongside other digital and electroacoustic instruments. The ensemble was well-suited for playing the instrument, as it is a collective of ambient electronic musicians who each have different instrumentation. See supplementary material for a recordings of one of these sessions (`excerpt_ensemble.wav`). This contributed in many ways to the practical development of the instrument, engaging in musical conversation with other performers.

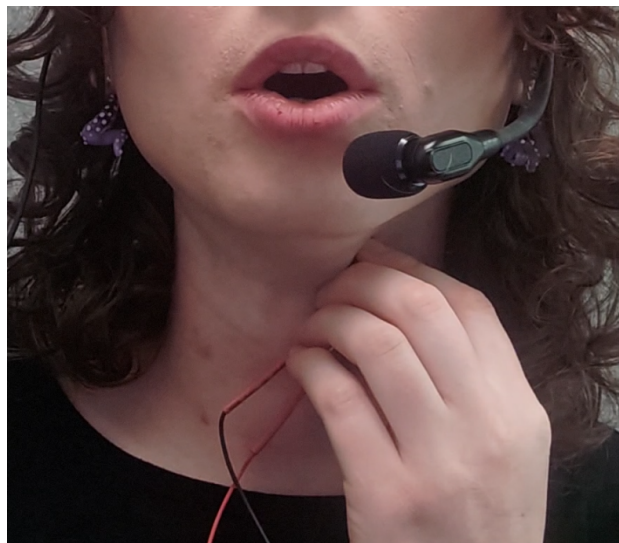


Figure 5: The musician wears a headset microphone, and places a transducer against their throat. Manual hand placement allows for musicality in terms of volume, making a muting dynamic in terms of contact with the throat.

Live Streaming over Twitch We live streamed the playing and development of *Ephemerides* over Twitch, a live streaming platform with special category for Science and Technology streams, twice for over an hour each, with the intention of generating both an online audience and a meaningful conversation about instrument after demonstration.

4 Discussion

In this section we draw on our findings from designing and performing with *Ephemerides* to elaborate on a few points of potential investigations. Considering the effects of applying technique from voice training therapy towards creative practice, we connect this instrument with models of access in DMI design. We use this design process and its findings offer provocations with the intention of breaking held assumptions surrounding marginalised people and creative practice.

4.1 Transness and the More-Than-Human

Homewood et. al. argue that more-than-human conceptions of the body allow for subjectivities beyond the sides of biological determinism and social constructivism [27]. Citing Elizabeth Grosz' corporeal feminism [22], they make note of how lived experience is shaped, not determined, by biological features. They draw a comparison with transgender embodiment and technological entanglements: "not only can bodies not be separated from all that surrounds them, whether these are animals, technological objects or societal or cultural constructions, but their combination produces something new" [27]. With *Ephemerides*, biological factors affect a musician's range for playing the instrument, but the musician's gender presentation in voice is muddled from cultural norms. The more-than-human conception affords a greater understanding of trans subjectivity as a longitudinal process of mental and physical transformation.

There is a connection between transness and the more-than-human. Steinbock suggests that "[f]eminism and transgender studies have paved the way to an understanding of how gender is

a kind of technology that makes the body culturally intelligible" [54, chapter 7]. More plainly, gender is a mediation between a physical body and social constructs. A transitioned voice, as a result of its technological entanglements, sociocultural factors, and biological references, demonstrates a clear example of a more-than-human entanglement.

4.2 Estranging the Vocal Apparatus

We observe an interesting connection between disrupting vocal production and disrupting voice as a biological 'essence'. As described in earlier sections, the process of designing Ephemerides shares many themes with soma design. Overriding the use of vocal cords actively disrupts voice production, giving an effect of defamiliarisation to the musician [58]. This effect provided a powerful method to explore making music with vocal resonance with a stronger focus on the larynx and tongue. There are further implications in directly manipulating the larynx to manipulate pitch. Sterne [51] suggests that, symbolically, moving away from the mouth as the origin of voice and towards the larynx as the source of vocal production involves a conceptual shift. A laryngeal vocalicity "renders vocalization as a process made up of many elements and components. The laryngeal voice is more like an instrument, less like magic or a soul" [51]. Especially when it comes to the consideration of gender presentation and voice, a laryngeal vocalicity sees gender not as a biological feature, but an expressive function of the oral cavity. Chadwick suggests, in light of critical frameworks, that we conceptualise voice not as a "static, self-contained and individual 'thing'" but as an emergent object and by-product of sociocultural factors [9].

It appears through our practice-led methods that this estrangement of voice also leads to a modified auditory imagery. First, while the unaltered use of vocal cords is inherently microtonal, in that vocal cords can sing any pitch in its range, Ephemerides produces a more specific sense of auditory imagery. In pre-constructing the microtonal scale and resonating it through the oral cavity prior to singing, the musician is better enabled to hear and thereby imagine a pitch in the microtonal scale. Second, Ephemerides directly affects the first author's sense of vocal dysphoria while singing. By using sinusoids on a transducer instead of using vocal cords, the sense of imagined gender in the sound is modified. This kind of auditory imagery is not pitch-based, but timbre- and culture-based. While Ephemerides did not move us closer to directly manipulating or modulating gender presentation in voice as originally desired, it appears to relocate the imagined sense of vocal identity in-between them and the Max patch.

We find it important to note that these observations are far from the desires of transhumanism, which often aim to dissociate from certain limitations of corporeality [20]. We intend the opposite: working with discomfort, dysphoria, and the limitations of the body provides a design space that honors differences in ability and gender expression [50].

4.3 Ephemerides and Access

Ephemerides is an instrument that was designed to better understand the phenomena of vocal dysphoria, and how this condition acts as a social barrier to singing. Vocal dysphoria is neither a physical barrier, nor a cognitive disability [26], making it an unusual grounds for considering whether this instrument is an ADMI. We wonder whether this research contributes to ADMI literature in that it, along with feminist critiques of NIME, challenges assumptions in DMI design that perpetuate an in-group of

white, cis male, and eurocentric participation [37, 59]. However, this contribution could loosen Harrison's thesis that an ADMI design requires consideration for both technical and social barriers [25], and could obscure the specific needs of disabled musicians.

We argue for more discussion in DMI research surrounding social access, whether or not it is considered ADMI research. Bates, through ethnomusicological study of the Saz and social negotiation process of designer and musicians, suggests a stronger consideration of the social role of instruments [4]. Within this negotiation we position social access as referring to who it is socially acceptable to be and how instruments are played in music settings. Experimental music, for example, provides a setting where breaking of traditional barriers in using voice is well-adopted [40], and a setting where playing Ephemerides is far from abnormal. A better awareness of the stigmas towards marginalised people and how these stigmas perpetuate would help.

Stigma, including internalised stigma, is something that affects more than trans people with respect to musical instruments. Frid notes that in addition to physical barriers to access, disabled people also face a stigma that results in social barriers to playing musical instruments [19]. This stigma is also faced by neurodivergent people in relation to musical instruments, when cognitive models do not match expectations for the 'right' way to learn or play an instrument [55].

Social access and accessibility are crucial considerations in making DMIs, and we turn towards disability studies for more critical understandings of these terms. Access can be both an opportunity for contact, as well as a refusal for assimilation [24]. Ephemerides shares a similar sentiment in standing in opposition to transnormativity, which is the idea that there is a correct way to transition, or that transgender identity is in conflict with gender non-conforming identities [17]. Even if gender based vocal training is used in clinical settings to achieve gender affirmation, it can still perpetuate transnormativity [44]. In the same way that traditional western music purports a correct and culturally viable method to playing an instrument, voice training often sifts into the same pitfalls. We view this instrument as a way to explore transgender voice training technique without prescribing a gendered goal as output.

4.4 Designing for Social Access

We suggest a depathologisation of differences in bodies, and that this concept has a role in DMI design. Depathologisation, as described by Cadwallar, is a political project not only to change viewing differences bodies as perversions, but to change the structures of the political bodies to support diverse needs [54, chapter 1]. The way that dysphoria is treated in the medical sense is a pathology, in which the trans body is viewed as sick for being trans [54, chapter 1].

We also suggest that depathologisation will enhance a culture in which differences and 'otherness' is celebrated. Co-design and participatory design help with achieving this, making instrument design a social process [60]. In addition, using language that applies towards general quality of life, rather than something that only applies towards a marginalised group is important for this. For example, championing "social play" and "self-regulation" as design qualities in a musical instrument does not designate that instrument 'for' autistic people, but it does address issues that members of the autistic community face [39]. While Ephemerides

makes use of techniques acquired through therapy, these techniques of manipulating the size and shape of the vocal tract can be used by anyone with the ability to.

5 Summary

Throughout this paper we explore designing with vocal dysphoria, a phenomenon that motivates gender-based vocal training, and how that phenomenon affected design decisions in the development of the microtonal vocal instrument Ephemeredes through vocal resonance. Our findings in practice-based research led to the formulation of many provocations surrounding access, stigma, gender presentation, and the technological means for exploring gender presentation. Conversations around access move beyond the individual or domain-specific making and into wider narratives that shape both institutional and personal practices.

Optimistically, we reflect on the opportunities DMI design possess in leveraging sociocultural negotiations, expressions, and differences towards using practice to inform technology. By designing instruments and incorporating them into artistic practice we can look inward and observe subjectivities, reconfigure technologies to express these subjectivities through music, and in doing so reconfigure ourselves.

6 Ethics Statement

We, the authors of this paper, follow the principles and codes of practice of NIME in our research. We use inclusive language where possible, use safe and environmental practices in the building of Ephemeredes by using a minimal amount of materials and resources, and we as authors are the sole individuals whose data and personally identifiable information is noted in the Positionality section. We plan to release our code as open source to adopt FLOSS/FLOSH (Free/Libre and Open Source Software/Hardware) with an MIT license further in the development of the instrument. We did not use generative AI models, human participants other than ourselves, or animals in our research process. The funding source for this research is part of the RUDIMENTS project, an ERC Consolidator Grant funded under UKRI Horizon Europe guarantee (EP/X023478/1).

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³<https://instrumentslab.org>

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