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GO WITH THE FLOW: WHEN LISTENERS USE MUSIC AS TECHNOLOGY

Andrew Demetriou ‡ Martha Larson § Cynthia C. S. Liem §
‡ Delft University of Technology, Delft, The Netherlands
§ Radboud University, Nijmegen, The Netherlands
andrew.m.demetriou@gmail.com {m.a.larson, c.c.s.liem}@tudelft.nl

ABSTRACT
Music has been shown to have a profound effect on listeners’ internal states as evidenced by neuroscience research. Listeners report selecting and listening to music with specific intent, thereby using music as a tool to achieve desired psychological effects within a given context. In light of these observations, we argue that music information retrieval research must revisit the dominant assumption that listening to music is only an end unto itself. Instead, researchers should embrace the idea that music is also a technology used by listeners to achieve a specific desired internal state, given a particular set of circumstances and a desired goal. This paper focuses on listening to music in isolation (i.e., when the user listens to music by themselves with headphones) and surveys research from the fields of social psychology and neuroscience to build a case for a new line of research in music information retrieval on the ability of music to produce flow states in listeners. We argue that interdisciplinary collaboration is necessary in order to develop the understanding and techniques necessary to allow listeners to exploit the full potential of music as psychological technology.

1 INTRODUCTION
When the word technology is used in the context of music, it generally relates to the development of new digital devices or algorithms that support the production, storage, and/or transmission of music. In this paper we break from the conventional use of the word technology in regards to music, reprising a conception of music as a technology in and of itself.

In order to understand precisely what music as technology means, it is helpful to take a closer look at the meaning of the word technology. Specifically, we use technology in the sense of a manner of accomplishing a task especially using technical processes, methods, or knowledge. We do not contradict the generally accepted perspective that music may exist for its own sake. However, we do take the position that other considerations may also be at stake when listeners listen to music. Specifically, we hold that there are cases when listeners use music as a tool that is directed towards accomplishing a task. In these cases, music can be considered as part of a method applied by listeners to achieve a goal.

The notion of music as technology was already coined in the area of sociology by DeNora at the end of the millennium [8]. This work characterized music as part of the continuing process of self-development, and posited that individuals use it to maintain and develop a social identity as well as a means to self-regulate emotions, moods, energy levels, or for the purposes of ‘self care’. In effect, it was suggested that people outsource various sorts of ‘emotional work’ to music, based on their goals within a given context.

We argue that the moment is now ripe for the music information retrieval (MIR) community to revisit this notion. In the intervening years, social psychology and neuroscience have considerably advanced our understanding of how music is used in everyday life, and how it effects the brain. Further, music recommender systems show signs that they are already reorienting themselves from music that users "like" to music that users find useful in a particular situation. This development is evident in the evolution of how the purpose of music recommender systems is described in the literature. A 2002 publication [36] characterized this purpose as recommending music that the user will be interested in, which contrasts with the statement of a 2011 publication [12] that a good recommendation system should...maximize the user's satisfaction by playing (the) appropriate song at the right time. Currently, the unprecedentedly large amount of music available online offers new possibilities of finding a tight fit with listener needs. Reflecting this focus, a 2015 publication [32] stated the purpose of music recommender systems to provide guidance to users navigating large collections. We draw on these contemporary findings and theory to understand how users may better use music as a tool in everyday life.

The contribution of this paper is to revisit and update the notion of music as technology, and to link it to a Call to Action for MIR and neighboring psychology-oriented communities. It should be noted that the sociopsychological concept of music preference as a potential indicator of personality, values and beliefs (and as a 'social badge') is relevant to music consumption behavior, fitting into the concept of considering music as a technology (to establish belonging), and not yet taken into account sufficiently in the context of music recommender

1 http://www.merriam-webster.com/dictionary/technology
systems [19]. However, in our paper the focus will not be on social listening, but rather on the complementary situation in which the listener consumes music on their own, in relation to achieving a personal goal.

In our consideration of a technological role of music, we go beyond ‘self-care’, and describe music as a tool that a listener may use to achieve the internal state necessary to accomplish their goal. We hypothesize that this connects to the concept of flow [24]: a desirable internal state that has been characterized by complete and total attention, a loss of a sense of self, a loss of a sense of the passing of time, and the experience that conducting the activity is, in and of itself, intrinsically rewarding. In other words, a listener in flow state is enjoying the feeling of being absorbed in their task to such a degree that the passing of time is not noticed, and is therefore able to push past obstacles to carry out activities and achieve goals. In later sections, we will elaborate on theories regarding the possible neurophysiological nature of flow states, the effects of music on the brain, and how it is that music may assist in achieving these internal states. As an initial indication of the growing importance of music that allows users to accomplish goals, we point to the growing number of artists’ and services’ on the Internet that are providing music to help people focus.

The idea of music as technology should not be considered a paradigm shift, but rather as the explicit identification of a common phenomenon. This phenomenon has thus far escaped the attention of the MIR community because the focus of music information retrieval research has been firmly set on what music is, rather than on what music does. However, there are many examples of work that illustrates the breadth of areas in which music is used as a tool to accomplish an end. Most widely known is perhaps the use of music as a meaning-creating element in storytelling, especially in film and video, e.g., [35]. Currently expanding is the use of music in branding, e.g., within the rise of the concept of corporate audio identity [2]. Less comfortable to contemplate is the use of music for torture e.g., as studied by Cusick [7]. Finally, we mention the therapeutic uses of music, as covered recently by Koelsch [17].

Our work differs in a subtle, but important way from these examples. We look at music as technology from the point of view of listeners who make a conscious decision to expose themselves to the experience of music to alter their internal state in order to achieve a goal that they have set for themselves. Later, we will return to the importance of listener control over the choice of music for the effectiveness of music as a tool.

Music as technology has serious implications for music information retrieval. If listeners may choose to use music as a psychological tool, then it is important for music search engines and recommender systems to be sensitive to the exact nature of the task that users wish to accomplish. It also is important for researchers to judge the success of these systems in terms of their ability to support users towards accomplishing tasks.

To understand music as technology more profoundly and fundamentally, collaborations between MIR and the neuro-, cognitive, and social psychological sciences, will be essential. Joint research lines involving collaborations between these fields will allow for the potential to determine when and how flow states occur, if they vary in any way based on context, and how exactly these states are aided by music.

In summary, this implies two places in which the MIR community should be active: i) learning and understanding what users need to put themselves into a flow state, and how this depends on what they are doing and on the surrounding circumstances, and ii) understanding how new music search engines and recommender systems can be designed to allow listeners to achieve flow states.

In the remainder of this paper, we first will review how music is used as part of daily life. After this, we consider the effects of music on the brain, subsequently connecting to insights in relation to achieving flow state. Based on our proposed viewpoint and the reviewed literature, we discuss how the MIR research agenda can be broadened in this light, and finish with a Call to Action for interdisciplinary work worth investigating.

2. LISTENERS USING MUSIC

2.1 Music as part of daily life

In the everyday life of the modern human, music has become a constant accompaniment to all manner of daily activities [27, 29, 34]. The advent of portable music devices capable of housing vast collections, the ubiquity of available musical data via streaming services, and the development of technology that allowed for greater ease of music production, have all lead to the consumption of music on an increasingly individual basis across an increasingly broad range of activities and contexts [10].

Music listening is a common occurrence in everyday life, yet rarely the sole focus of an activity. A number of studies have pointed to this conclusion, and we mention some key examples here. In an experience sampling study where participants completed brief surveys at random intervals throughout their day, 44% of the surveys were completed while music listening had taken place within any 2-hour period, yet less than 2% of episodes involved listening to music as a main activity [32]. A later study showed that 38.6% of text messages sent to participants randomly throughout the day occurred during music listening occasions; on occasions where the participants were not listening to music, 48.6% indicated that they had listened to music since the last text message, yet only 11.6% of these episodes occurred when music listening was the main activity [27]. A more recent survey study has shown similar results, with respondents indicating a mean of less than 1 hour of active music listening per day, yet 2-4 hours of passive music listening [15].

Along with an increase in music consumption accompanying other activities is the emergence of the belief that individual music selections function as a means to

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1 e.g., Delta Notch, https://www.youtube.com/user/DDRFrosh1
2 e.g., Focus at Will https://www.focusatwill.com
achieve various emotional, motivational, or cognitive effects to the benefit of accomplishing various activities [27]. Individuals will report that music is expected to perform different functions based on different situations [26], an awareness of the specific sounds expected to fulfill those functions, as well as the expected psychological benefits from listening [8]. As such, people have come to use music as a piece of technology in their daily lives, effectively attempting to outsource various psychological tasks to specific song selections. We now go on to discuss the factors that contribute to listeners successfully using music to achieve internal states that may be described as flow, which, in turn, support activities or goals.

2.2 Choosing music for a purpose

As mentioned above, our perspective on music as technology regards music as a tool in the hands of listeners themselves. In this section, we examine in more detail the importance of listener control of music. The perceived benefits of music listening have been shown to be more positive when the individuals had the ability to choose the desired music [27]. Participants indicate preferring playlists they created rather than automatically curated content [15], and those who chose the music they were listening to reported enjoying it more [27]. Furthermore, with greater control on the choice of music selection, individuals reported experiencing greater changes in mood along three bipolar factors: 1) positivity, 2) present mindlessness, and 3) arousal [34]. Listeners’ preference for control is consistent with the idea of music being a means to an end. A number of studies have shown that listeners use music as a psychological tool to optimize emotion, mood, and arousal based on the very specific needs of a given situation and/or activity [8, 27, 34]. Interviews have shown that individuals have an awareness of specific songs they feel will assist in accomplishing various emotional tasks, such as decreasing or increasing their arousal, motivating them to take action, adjusting their moods, or assisting them to focus [8]. Reasons for listening to music have also been shown to vary by activity (e.g., doing housework, travelling, studying, dating, getting dressed to go out etc.) [8, 15, 29].

Along with the constant growth of the music corpus, a means to organize, retrieve and discover appropriate music selections is a growing challenge. Despite the prevalence of current playlist curation technologies, individuals report self-generated playlists to be the organizational method of choice [8, 15], an indication of the specificity of song selection requirements, above and beyond the specificity of individual preference. In the final section of the paper, we will return to discuss how, in order to use music as technology, users must have at their disposal appropriate music information retrieval technology. Next we turn to the neuroscience perspective on music as technology.

3. MUSIC AND THE BRAIN

Research in the field of music and emotion suggests there are multiple means for music to affect the individual, and that underlying physiological and neurological mechanisms should be researched [14]. We highlight two posited mechanisms relevant to our discussion: a) brain stem reflexes, and b) musical expectancy.

The degree and manner in which each mechanism results in a physiological or neurological response, and by extension arousal, may be key in understanding why listeners select specific songs given the tasks they have set out to accomplish. As the demands of each situation vary, the effect of acoustic stimuli on the brain of the listener may function to moderate arousal such that an optimal internal state is reached. In other words, listeners may be selecting songs, and by extension sequences of acoustic stimuli, to alter their internal state in order to best meet the needs of their situation.

3.1 Brain stem responses

The brain stem is believed to be a very old part of the brain, and has been shown to be sensitive to loud, low frequency, dissonant, suddenly changing sounds [5, 9, 22]. It is posited that sounds indicative of a sudden change, a strong force, or something of large size may coincide with an event that requires immediate, urgent and reflexive attention. These acoustic qualities shift attention to the stimulus, giving rise to muscular and cardiovascular responses as well; a by-product of this may be the reason bass drum sounds inspire people to dance in sync with the music, and why music with faster tempo is more arousing (see [14] and [17]). Furthermore, a greater number of brain regions have shown activation at the onset of musical samples as opposed to the middle or end of these samples [23].

As such, music that contains such acoustical stimuli, or dramatic changes in its acoustic features (e.g., dramatic build ups and “drops”), may shift attention to the music arousing the listener in the process. Conversely, music that is relatively constant may instead serve to drown out distracting ambient sounds instead: for example, the difference between silence and the rustling of papers is far greater than the difference between the rustling of papers and background music. As such, music may provide a constant acoustic backdrop thereby reducing the amount of arousal and attentional shifts caused by distracting sounds in the listener’s environment.

3.2 Musical expectancy

Recently, an increasing amount of attention has been devoted to expectancy as it relates to music (e.g., as in Huron’s recent work [11]). The ability of the human brain to predict events is thought to have been vital to survival, and thus plays a prominent role in all cognition. As such, meeting or violating expectations in music should result in physiological and neurological effects (see [30] and [31]). Given that music is essentially an organized pattern of sounds, our brains generate predictions as the music unfolds over time based on our knowledge of the specific musical piece, but also our knowledge of all music [31].

As only so much information may be encoded at a time, the more complex the piece, the greater the number of potential prediction errors, the more exposure is required to become familiar [31]. In fact, as far back as Berlyne’s [3] studies, it has been shown that familiarity of a particular sequence of notes in relation to a corpus results in less physiological arousal than unfamiliar sequences of notes,
as does simplicity in the melody as opposed to complexity. These expectations may be used deliberately by composers of music to create a sense of musical tension, only to resolve the tension later on in the piece, resulting in relaxation and pleasure [18]. In addition, familiarity of a piece may lead to anticipation of the pleasure to be experienced at peak moments in the music, resulting in the activation of midbrain dopamine neurons causing attention to be paid to potential upcoming rewards [31]. Relevant to our topic, such arousal may divert attention from the task to the music [e.g., 13]. On one hand, music that adheres to expectations, such as a collection of very familiar pieces, may result in less overall arousal than pieces that are unfamiliar, very complex, or of an unfamiliar genre. On the other hand, familiar pieces that result in pleasure and anticipation may also be arousing, diverting attention from the task to the music as well.

4. MUSIC AND FLOW

Flow is characterized as a mental state in which one’s complete attention is focused on a task, one has lost sense of self and of time, and one’s perception of the experience is positive and rewarding [24]. In this research tradition, the definition of flow also includes a sense that one’s subjective level of skill is balanced with the subjective challenge of the activity: a too-simple task evokes relaxation then boredom which in turn causes attention to drift, and a too-challenging task evokes vigilance then anxiety [24]. As with music use in everyday life, the concept of flow is also intertwined with context and activity.

More recently it has been theorized that flow states may emerge during media enjoyment, resulting in neural states where attentional and reward centers in the brain are activated synchronously [40]. Weber and colleagues [40] drew a theoretical link between engagement in linear media (e.g., books, films and video games) and flow states. They posit that linear media require mastery of mental models: video games require a level of skill that increases as one progresses, and films require an understanding of the characters and the narrative. It is suggested that these contribute the challenge, which in addition to pleasurable engagement, coincides with activations of the brain regions necessary to achieve flow. While music is not specifically discussed, it is a medium that can be consumed during various activities, and may function in conjunction with these activities to inspire flow states.

The dopaminergic pathway, which is involved in the experience of pleasure, is posited to be active during flow states [40], and has been shown to be active during experiences of pleasure while listening to music [31]. Of interest in this pathway is the nucleus accumbens, which is also thought to be involved in automatic consummatory behavior (e.g., drinking or eating), and the striatum which also has connections to the brain stem [40]; both also been observed in pleasurable responses to music [31]. In addition, regions thought to be involved in reward-seeking behaviors, such as the prefrontal and orbitofrontal cortices have also been implied in both [31] [40].

While it is not yet clear how specifically music and context may interact to produce a flow state, enough evidence has been accrued for us to suggest two aspects worthy of study. Firstly, during tasks in which boredom is likely, more arousing music may be selected to induce a flow state: by diverting attentional resources to the music the challenge of the task increases, as it now requires attention to be paid to both the activity and the music. As such, music that is more likely to be arousing either by a) resulting in responses from the brain stem (e.g., loud, frequently changing, or dissonant song selections) or b) causing prediction errors (e.g., less familiar, familiar and causing anticipation, or more complex) may be more suitable. Secondly, during tasks that are challenging or otherwise cognitively engaging (e.g., studying or reading) music that is likely to be less arousing either by a) resulting in less brain stem activation (e.g., relatively unchanging or consonant) or b) being predictable without anticipation (e.g., somewhat familiar and somewhat liked, more simple songs) may be more suitable.

5. NEW CHALLENGES FOR MIR

We now turn back to discuss how music as technology connects with MIR. The ability of listeners to successfully use music as technology depends on the effectiveness of music information retrieval and recommender systems in supporting them. We argue for the necessity of multi-disciplinary research that brings together neuro-, cognitive, and social psychologists, and music information retrieval researchers. Such collaboration will allow us to understand what makes music helpful for users and what makes it appropriate for different tasks. In this section, we point to several areas in which the music information retrieval is on the right track, and several areas in which more effort is needed if users are to truly benefit from music as technology.

First, we return to the relation between the user choosing music, and music being perceived as having positive benefits. Taking this connection seriously means taking the position that for music to be used effectively as technology, it must truly be a tool in the users’ hands (i.e., fully under the control of the user). Other work that points out the critical role of user control over music selection includes [38], who observe that the context and the intentions of the user impact which music features are important. Their music selection interface provides users with control over factors such as tempo, mood, and genre, and their experiments show that users prefer this control. The findings are not surprising given the role of control in the success of recommender systems from the user point of view [28]. In order to make music a useful tool, MIR must start with the choice of the listener to change their internal state in order to accomplish a goal. The choice may be semi-conscious, or may simply consist of going to a place where certain music is playing, or accepting to stay in that place. Listeners who are unwilling or who are not themselves in control are not using music as technology. In other words, piping in focus music during an exam can be predicted not to improve students’ ability to concentrate. MIR systems can make music useful as technology by providing results and recommenda-
tions that are transparent. The importance of transparency for recommender systems has long been recognized [33]. They should also minimize the effort needed from the user to provide feedback.

Second, serving listeners who want to use music as a tool requires extending today’s context-aware recommender systems, which are described, for example, in [32]. Particularly promising is the development of systems to recommend music for activities, e.g., [39]. In [25] the authors propose a context-aware music recommendation system the monitors heart rate and activity level, and recommends music that helps the user achieve a desired heart rate intensity. The challenge of such activity-based recommenders is to provide music that serves the common needs of people engaging in an activity, while taking personal taste into account. One aspect of using music as technology is blocking out background noise. Context-aware recommenders will need to develop to be sensitive to the acoustic environment, so that they can recommend music that will mask it.

A challenge that has yet to be faced is moving music recommendation and retrieval away from music that listeners "like" the first time that they hear it, towards music that allows them to meet their goals. Currently, the ground truth that is used to evaluate the success of recommender systems does not differentiate “love at first listen” from an appreciation that a listener develops over a longer period of time on the basis of utility given the context and activity.

We suggest that collaboration between MIR and psychology may be appropriate to best determine not only how music can better be organized to suit different tasks, but also which specific features make certain music helpful, or make one selection more suitable for a given activity than another.

Recent years have seen progress in content-based and hybrid music recommender systems [32]. These systems make use of timbral features (e.g., MFCCs), features related to the temporal domain, such as rhythmic properties, and tonal features such as pitch-based features. Our discussion revealed the importance of content features that might point to a sudden, unexpected event in the music that would shift the listener’s attention. We point out that recent approaches to exploiting music content may only use very short segments of the music, such as the deep learning approach in [37]. A future challenge is to determine how long a window must be considered in order to determine whether the song contains features that disrupt focus. Here again, task specific as well as user-specific aspects are important.

Further, the role of familiarity is critical. The importance of music freshness is well recognized. For example, Hu and Oghihara [12] relate it to a memory model. However, playing the same familiar music repeatedly does not promote focus if the user's sense of anticipation becomes too strong. With the vast amounts of music currently available online, the possibility is open to creating a music recommendation system that never repeats itself.

When music is used as technology, it is important to keep in mind that it is the stream and not the individual song that is important. Currently, an increasing amount of work is carried out in the area of playlist recommendation [4]. Whereas many playlists are played on shuffle, playlists that most effectively allow the user to achieve internal state transformation may have a particular order, calling for more work on the generation of ordered streams of content items.

Finally, we anticipate that when listeners use music as technology they will want the possibility to query the system, instead of relying on a recommendation. Such queries, even though context-based, may not be well fitted to the goal that they want to accomplish. Here, it is necessary to understand the type of language that users use to express the complexity of their task. To this end, the MIR community should further foster insights in information seeking and user studies. However, an important difference with the existing paradigms under which these studies are conducted (e.g., [6, 20]) is that under the ‘music as technology’ paradigm, a query would be expressed in the form of a (non-musical) task to be accomplished, rather than a directed query to an explicit song (e.g., similarly to what was done in [21] on music and narrative).

6. CALL TO ACTION

In this work, we pointed out the notion of music as technology, which we feel currently is overlooked in MIR solutions. Connecting this concept to existing literature from the psychological sciences, it is clear that pursuing a joint research roadmap will be beneficial in both gaining fundamental insights into processes and internal states of listeners, and finding ways to improve music search engines and recommender systems. To concretize this further, we conclude this paper with a Call to Action, formulating interdisciplinary research directions, which will be beneficial for realizing the full potential of music as technology.

First, research should contribute to a better understanding of flow states. The evidence brought together in this paper points to the conclusion that flow is a desirable overarching internal state, and is the target state underlying a wide range of activities. We further argued that listeners choose music that complements an activity to result in a net optimal level of cognitive engagement. Under this view, music is not an end unto itself, but rather an inextricable part of the activity. More research is needed to validate flow as an overarching mental state in practice, as well as its antecedents. In addition, how music leads to and moderates flow state should be investigated.

Second, on the basis of a deeper understanding of flow, research should work to define new relevance criteria for music. Such work will involve understanding which kinds of music fit which kinds of tasks, zeroing in on the relevant characteristics of the music. We expect this to be a formidable challenge, since it must cover perceptual, cognitive, and social aspects of music. The contribution of users’ personal music experiences and music tastes must also be understood. On the one hand, we anticipate a certain universal character in the type of music that will allow a person to achieve flow state for a given activity. On the other hand, we anticipate that a ‘one size fits all’ solution will not be optimal, and that relevance criteria
must also be flexible enough to capture individuals’ needs and preferences. Third, once we have defined relevance criteria, we should move from there to identify new features, new algorithms, and new system designs. We anticipate that features reflecting music complexity and unexpectedness will be important, as a few relatively isolated disruptive moments can potentially make an entire song unsuitable for an activity. This observation points to the need to consider the song as a whole, implying, in turn, new MIR algorithms. New system designs will be needed to help guide users’ music choice without effort, and ideally without interrupting their flow state. System designs will need to take into account that users may not recognize the music that will make them most productive the first time they hear it. Further, even after listeners recognize the connection between certain music and their own productivity levels, they might not be able to express their music needs explicitly in music-technical terms. Systems must be able to accommodate the types of information and feedback that users are able to provide about the kind of music that will be most effective for them.

Finally, once new applications have been developed and deployed, they will provide an extremely valuable source of information about how listeners use music, allowing neuroscientists and psychologists to refine their theories of flow and how listeners achieve it in certain situations, against the backdrop of scalable and real-world use cases. Our suggestion for MIR and the (neuro)psychological sciences to connect is not new; for example, it also was reflected upon in [1], and recently further interconnection possibilities between the disciplines were suggested in [16]. Both of these works rightfully point out that such collaborations are not trivial, particularly because of methodological differences and mismatches. However, we believe that the currently described possibilities offer fruitful research questions for all disciplines.

Ultimately, understanding music as technology has the potential to profoundly impact not only the MIR domain, but the whole ecosystem of music production, delivery and consumption. Currently, the success of music is judged by the number of downloads or the number of listens. The idea of music as technology opens up the possibility of evaluating the success of music also in terms of the goals that are achieved by listeners.

Besides considering music as technology, we believe that we also should continue to study and enjoy music for its own sake. However, the potential of music to help listeners achieve their ends opens the way for creative new uses of music, with respect to commercial business models, as well as promoting the well-being of listeners. We hope that ultimately, music as technology will support listeners in coming to a new understanding on how they can use music to reach their goals and improve their lives.

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7. REFERENCES

A LOOK AT THE CLOUD FROM BOTH SIDES NOW: AN ANALYSIS OF CLOUD MUSIC SERVICE USAGE

Jin Ha Lee
University of Washington
jhalee@uw.edu

Yea-Seul Kim
University of Washington
yeaseull@uw.edu

Chris Hubbles
University of Washington
chubbles@uw.edu

ABSTRACT
Despite the increasing popularity of cloud-based music services, few studies have examined how users select and utilize these services, how they manage and access their music collections in the cloud, and the issues or challenges they are facing within these services. In this paper, we present findings from an online survey with 198 responses collected from users of commercial cloud music services, exploring their selection criteria, use patterns, perceived limitations, and future predictions. We also investigate differences in these aspects by age and gender. Our results elucidate previously understudied changes in music consumption, music listening behaviors, and music technology adoption. The findings also provide insights into how to improve the future design of cloud-based music services, and have broader implications for any cloud-based services designed for managing and accessing personal media collections.

1. INTRODUCTION
The last decade has been marked by significant and rapid change in the means by which people store and access music. New technologies, tools, and services have resulted in a plethora of choices for users. Mobile devices are becoming increasingly ubiquitous, and different access methods, including streaming and subscription models, have started to replace the traditional model of music ownership via personal collections [30]. Cloud-based music services are one of the more recently developed consumer options for storing and accessing music, and the use of cloud-based systems in general is expected to increase in the near future. As the popularity of cloud computing grows, a number of studies have been published regarding uses and attitudes of cloud-based systems (e.g., [21]). However, few studies specifically investigate cloud-based music services; many questions regarding the use of those services are virtually unexplored. For instance, what makes people choose cloud-based music services, given numerous streaming choices for accessing music? What works, and what does not work, in existing services, and how can user experiences be improved? What opinions do users hold about cloud-based services, especially regarding the longevity, privacy, and security of such systems? Answering these questions will help elucidate the challenges users are facing in today’s complex music access environment, and will inform future music access and organization models.

In this paper, we aim to answer the following research questions: 1) How do people commonly use cloud music services and manage their cloud music collections, and how does streaming usage interact with, support, or supplant cloud music usage?; 2) How do users explain their preferences for particular cloud music services and functionalities?; 3) What do users perceive as limitations of current services, and what kinds of features do users want in a cloud-based music access and management system?; and 4) Are there significant differences in perceptions and usage of cloud music services which correlate to demographic differences, such as age or gender?

This study is part of a larger agenda seeking to empirically ground current understandings of music collecting and information-seeking behavior. The explosive growth of cloud services in the past five years has demonstrated a burgeoning, robust commercial market of products which will benefit from new empirical analyses. This work is critical in an age where technology and society undergo upheavals so frequently that previous models of human activity often prove to be oversimplified or obsolete when applied to new problems. Empirical work in this area has implications for device and software design and development, structuring of metadata, consumer behavior, and music industry planning, in addition to offering contributions to academic theory in multiple disciplines.

2. RELEVANT WORK
Cloud computing has exploded in popularity since the mid-2000s, and scholarly inquiry on the topic has correspondingly increased. User studies of cloud services have found a variety of factors influencing consumer adoption and retention of cloud services, including ease of use and on-demand ubiquity [24, 28], functionality and perceived usefulness [1, 28], accessibility across web-enabled devices [21], and support for collaborative projects [21, 24]. While online music discovery and consumption has also grown dramatically over the course of the nascent 21st century, cloud platforms designed specifically for music listening and storage are still relatively new; for instance, Apple iCloud and Google Play Music, two major competitors in the cloud music marketplace, both launched in 2011. A great deal of speculative and anecdotal literature has arisen around cloud music, including on the cloud’s philosophical implications and its potential to disrupt so-
cioeconomic and cultural notions of ownership [4, 22, 30]. However, actual user attitudes toward services and behavior within these services remain underexplored, reflecting a general lack of focus on user experience in MIR studies [27]. Furthermore, cloud services afford and facilitate functions such as transfer of files between devices, automated organization of files and metadata, sharing, and backup, which previously were cumbersome but common user tasks [3]. User behavior thus may have changed significantly, or be in transition, from that described in studies which are only a few years old.

Cloud music services also complement, or compete with, streaming services for listeners’ ears. User behavior on streaming services has received more empirical attention as the popularity of platforms like Spotify and Pandora has swelled. Hagen [9] conducted a mixed-methods study to examine playlist-making behavior in music streaming services, finding a heterogeneous set of management and use strategies. Kamalzadeh et al. [14] investigated music listening and management both online and offline, and found that streaming service use was less frequent than offline listening to personal digital music collections. Lee et al. [15, 16] inquired into user needs for music information services and user experience within commercial music platforms, noting increased use of streaming services and exploring opinions about services and features in some depth. Zhang et al. [31] examined user behavior on Spotify through quantitative analysis of use logs, focusing on device switching habits and frequency and periodicity of listening sessions. Liikkanen and Aman [19] conducted a large-scale survey of digital music habits in Finland, finding that online streaming through Spotify and YouTube were predominant. Cesareo and Pastore [5] and Nguyen et al. [23] both executed large-scale surveys of streaming music use to assess consumer willingness to pay for services and streaming’s effect on music purchasing and illegal downloading. However, detailed user-centered studies which examine both cloud and streaming services in concert are lacking in the extant literature.

Our study seeks to enrich understandings of online music listeners’ needs, desires, attitudes, and behaviors through a large-scale survey of cloud music usage. We also seek to explore whether differences in behaviors and attitudes about cloud and streaming services correlate to demographic differences, particularly age and gender. Music sociology, music psychology, and music information studies researchers have noted gender differences in some aspects of music tastes [8], experiences [18], and listening habits [7, 8], but not others [6, 13, 26]. Technology use can also differ markedly by gender, e.g. in choice of smartphone applications [25], and in adoption and use of mobile phones [12] and social networking services [10]. Comparatively little attention has been paid to whether and how these differences are mirrored in online music service usage; exceptions include Berkers [2], who used Last.FM user data to examine differences in musical taste between genders, and Makkonen et al. [20] and Suki [29], both of whom found gender and age differences in online music purchasing intentions.

3. STUDY DESIGN AND METHOD

This study is a follow-up to an earlier project which investigated current cloud music usage and the future of cloud music practices through semi-structured interviews with 20 adult and 20 teen users [17]. This study seeks to validate findings from the interviews and surface new insights by surveying a larger number of cloud music service users.

The online survey consisted of 24 questions which asked about users’ cloud music service usage, cloud music collection management, and general music listening behavior. Our question set was generated after the completion of the interview project, and so our choice of questions was partly informed by our interview findings. Participants were recruited via online venues such as e-mail lists, Facebook groups targeted for students attending the University of Washington, the first author’s social network websites, Craigslist, and several online listservs and forums related to music (e.g., ISMIR community listserv, AllAccessplaylists reddit). We also distributed and mailed flyers to 50 physical venues including campus locations, record shops, businesses, libraries, and community centers. Participants were offered an opportunity to enter their names in a raffle to win Amazon.com gift cards.

The survey data included quantitative numerical responses, radio-button and check-all-that-apply multiple choice questions, and free response text boxes. Quantitative data was processed via SPSS and Microsoft Excel. Answers from open-ended questions were qualitatively coded by two coders, employing an iterative process. The codebook from [17] was adopted as an initial framework, and then was slightly expanded and revised after the first round of coding to fully represent the themes in all responses. Afterwards, we adopted a consensus model [11] where two coders compared their coded results and discussed instances where disagreements in code application occurred, aiming to reach a consensus.

Our recruitment methods, both online and real-world, often centered on areas populated by young adults in their twenties and thirties, and while it seems intuitively reasonable that this population would be more likely to patronize cloud services than other demographics, there may be significant cloud-using populations we did not reach. Our outreach efforts occurred mostly within the United States, especially the Puget Sound region, and while we allowed for worldwide access to the survey, the majority of our respondents were Americans. Of our survey respondents, over 70% were male, which may not necessarily be indicative of actual cloud usage patterns.

Despite employing a variety of recruitment tactics and publicizing the survey in several waves, we received a total of 371 responses, of which 198 were complete responses. Since cloud services are a relatively new service industry, we speculate that our recruitment difficulties may be due to a general lack of widespread adoption. Furthermore, many online music consumers are electing to use streaming rather than cloud platforms, making them ineligible for our study.
4. FINDINGS AND DISCUSSION

4.1 Participants’ Demographics and Characteristics

The average age of participants was 29.7 (Stdev: 8.5). Most participants (80.8%) were from the United States, with the rest from Canada, the United Kingdom, and 16 other countries. 70.7% of respondents were male, 27.8% were female, and the rest selected ‘other’. Participants listened to a wide variety of music as well as spoken-word audio (e.g., comedy, podcasts), with rock, pop, and electronic music being the most preferred genres.

4.2 Usage of Cloud Music Services

Of the three most commonly used cloud music services, Google Play was the predominant service (71.7%), with about a quarter of respondents using each of the other major services (Amazon Cloud, 25.8%; Apple iCloud, 23.7%). These services were primarily accessed by smartphone (91.9%), laptop (75.8%), desktop computer (60.1%), and tablet (51.5%). Devices designed specifically for music listening, such as cloud-enabled home stereo systems (e.g., Sonos) (10.6%) and portable music players (8.1%), were much less common. The average reported length of cloud music service use was 35.5 months (Stdev: 25.8). The frequency of service use tended to be high; 66.2% used them on a daily basis (‘almost every day’ or ‘more than once a day’), and 20.7% on a weekly basis (‘about once a week’ or ‘a few times a week’).

Table 1 summarizes how participants reported using cloud music services. Easier access to music which users may or may not own was the primary reason for using services, followed by discovery, preservation, management, and sharing purposes. When they do use cloud services for discovery of new music, 59.6% relied on an automatically-generated playlist or using a cloud radio feature, 41.9% relied on new music suggestions by the service (e.g., advertisements or promotions), and 23.7% took suggestions from friends on the cloud. Approximately one out of four participants (25.3%) did not use cloud services for discovering new music. In the prior study, interviewees reported that they primarily rely on streaming services like Spotify and Pandora for music discovery [17].

<table>
<thead>
<tr>
<th>Usage of cloud music services</th>
<th>Total (n=198)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To stream music from my collection</td>
<td>171 (86.4%)</td>
</tr>
<tr>
<td>To listen to music I do not have in my collection</td>
<td>138 (69.7%)</td>
</tr>
<tr>
<td>To discover new music or get recommendations about songs and artists</td>
<td>128 (64.6%)</td>
</tr>
<tr>
<td>To hold copies of my digital music files in case my hard drive dies</td>
<td>97 (49.0%)</td>
</tr>
<tr>
<td>To transfer digital music files between computers and/or mobile devices</td>
<td>89 (44.9%)</td>
</tr>
<tr>
<td>To share music with other people</td>
<td>38 (19.2%)</td>
</tr>
</tbody>
</table>

Table 1. Usage of cloud music services.

4.3 Management of Cloud Music Collections

The median value of the estimated size of participants’ music collections was 2,908 songs (1Q: 300, 3Q: 10,000, max: 100,000) or 29.74 GB of disk space (1Q: 5.75, 3Q: 60, max: 2,500). While many participants had sizable collections, organization was not a pressing issue for most of them, as 72.2% stated they relied on automatic organization by the service, compared to 24.2% who manually organize their collections. 56.6% of participants responded that they have music that is not uploaded to the cloud. The reasons varied, from lack of time/resources to issues of limited access (presented in Table 2).

<table>
<thead>
<tr>
<th>Reasons for having music not uploaded to the cloud</th>
<th>Total (n=112)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have not had time to add all of them yet</td>
<td>63 (56.3%)</td>
</tr>
<tr>
<td>I have enough music in the cloud for my needs right now</td>
<td>40 (35.7%)</td>
</tr>
<tr>
<td>They are physical items that are hard to digitize</td>
<td>36 (32.1%)</td>
</tr>
<tr>
<td>My cloud storage is limited</td>
<td>30 (26.8%)</td>
</tr>
<tr>
<td>I prefer listening to physical items for some music and/or like to have physical copies of things as well</td>
<td>28 (25.0%)</td>
</tr>
<tr>
<td>They are physical items which are not readily accessible to me</td>
<td>15 (13.4%)</td>
</tr>
</tbody>
</table>

Table 2. Reasons for having music not uploaded to the cloud.

Although 55.1% of participants responded that they purchase or obtain music from cloud services, few did so frequently, with approximately three out of four participants (72.5%) doing it about once a month or less.

We also asked participants whether they back up their music collection in general, and if so, what kinds of strategies they use. Of all participants, 58.6% responded that they do back up their collection; of those answering yes, 48.3% keep local copies of music files as backup on a secondary storage device, and 11.2% keep copies on a computer. Some participants considered the cloud music services to be their backup (23.3%) or backed up their music in the cloud using another cloud service such as CrashPlan or Google Drive (8.6%). Most of the backup efforts were done in digital file formats; only 3.4% kept physical copies of CDs, vinyl, etc. as backup.

4.4 Music Listening Behavior

YouTube (65.8%), Spotify (57.8%) and Pandora (52.9%) were the most popular streaming services, followed by SoundCloud (40.6%) and Last.FM (23.5%). With the increasing availability of music streaming features offered by cloud and other online music services, we wanted to know how much of the music our participants listen to is actually owned by them (versus access via streaming). As shown in Table 3, the proportions of participants who almost always own or almost always stream the music they listen to were about equal. Approximately one out of four listen to owned music and stream music about the same amount. Overall, the distribution is fairly spread out
across the different categories, although there were slight-
ly more participants who tend to stream more than own-
music rather than the vice versa.

<table>
<thead>
<tr>
<th>Ownership vs. Streaming</th>
<th>Total (n=197)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I own almost all the music I listen to</td>
<td>29 (14.7%)</td>
</tr>
<tr>
<td>I mostly listen to the music I own, but sometimes stream music I don’t own</td>
<td>36 (18.3%)</td>
</tr>
<tr>
<td>I listen to music I own and stream about the same amount</td>
<td>52 (26.4%)</td>
</tr>
<tr>
<td>I mostly stream music I don’t own, but sometimes listen to the music I own</td>
<td>50 (25.4%)</td>
</tr>
<tr>
<td>I almost always stream music I don’t own</td>
<td>27 (13.7%)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (1.5%)</td>
</tr>
</tbody>
</table>

Table 3. Ownership versus Streaming.

89.4% of participants responded that they use playlists. Criteria for generating playlists included personal preference (72.3%), mood (59.9%), genre/style (55.4%), accompanying activity (e.g., working out, partying, traveling) (50.8%), artists (35.6%), and recent acquisition (33.3%). More than half of participants (53.1%) listen to playlists that are automatically generated by the services instead of (or in addition to) creating their own.

4.5 Selection Factors, Perceived Limitations, and Desired Features

We asked respondents how they came to use cloud music services, what they desired from the services, and what kinds of limitations or frustrations had surfaced in their usage of the services. When asked how they initially found services, respondents chose the option ‘I sought out cloud services to fit my music listening needs’ most frequently from a predetermined list of choices (47.0%). Others had cloud services preinstalled on devices (21.7%), found out from friends or family (21.7%), through advertising (20.7%), or were signed up automatically due to an existing connection with a cloud provider (12.6%). Free-form responses given via the ‘other’ option indicated that several users discovered their cloud service providers through Internet information sources, such as press coverage or blog posts (11 responses). 64.1% of respondents were paying for cloud music access.

We also asked users which service they preferred of those they had tried and why. 184 users responded to this open-ended question, though 15 of them noted that they only used one service. Qualitative coding of the responses indicated that the most popular reasons were device compatibility (29.9%), ease of upload and size of storage space (23.4%), brand loyalty (19.0%), price (18.5%), and variety and availability of desired music (16.3%). A representative user explained that he chose Google Play Music “because 1) I use an Android phone & tablet, 2) they uploaded my library to their cloud, 3) I jumped on early & have a discounted monthly price.” (ID: 103)

51.0% of participants responded that there is something they would like to change about the service they use. From a predetermined bank of answers, users indicated that the most common factors hindering their use of services were lack of good sharing features (40.6%), clumsy or unappealing visual design (30.7%), poor general functionality or hugginess (30.7%), other missing features (26.7%), difficulties with transferring music (22.8%), high cost (11.9%), device compatibility issues (9.9%), and a lack of storage space (7.9%). Free-form responses to this question indicated that song access was also an issue for some users, due to services’ incomplete artist libraries or problems uploading certain file formats. Other free-form responses from dissatisfied users related to suboptimal playlist or automated radio features, poor organizational or metadata-curating functionalities, streaming options (such as lack of support for simultaneous streaming from multiple devices), and sharing.

We also asked whether and why users would consider switching to another service. Of the 170 respondents who answered this question, 47.6% indicated they would consider switching, while 34.7% indicated they would not, and 17.6% answered that they might switch or were non-committal. Of those who said they would switch, pricing was by far the most common reason given (43 responses), with artistic selection (21) and device compatibility (17) distant runners-up. For those who said they would not switch, the most common thread underlying responses (11) was a sense of inertia. Moving collections from service to service is time-consuming and cumbersome, making it unappealing to users who have settled in with a cloud provider — especially if the user has bought into a full software/hardware combination (such as Google Play Music and Android devices, or iCloud and Apple devices). For instance, one user noted, “I would not consider switching at this time. It would be a hassle to move my personal music collection to a new service.” (ID: 342), and another replied, “Only if I were to switch to another mobile ecosystem.” (ID: 197) The need for compatibility across devices and services surfaced repeatedly in qualitative coding of the no-switch responses (9 codes, plus some inertia comments obliquely referenced this); other concerns include artist selection (8), upload/storage needs (7) and price (7). Pricing, artist selection, and device compatibility also surfaced in the replies of the maybe-switch respondents, making these common concerns.

4.6 Differences in Gender and Age

We initially speculated that there might be marked differences in cloud service usage by age based on the fact that cloud services were introduced recently, but our data indicate that age, overall, was a relatively minor factor in explaining cloud service usage variability. We divided the participants into three age groups of approximately equal size (25 and younger, 26-30, 31 and older) and ran chi-square analyses on the responses for most of the survey questions (excluding open-ended questions) to identify statistically significant differences. Significant differences between age groups were observed in questions regarding music purchase and paying behavior, as well as in choice of device for accessing cloud music services. Participants who were 31 or older were more likely to pay to use cloud services ($X^2=11.34, df=2, p=0.003$) (cf. Makkonen’s [20] findings regarding age and willingness to pay for music downloads). Older par-
participants also tended to access cloud music via desktop computers ($X^2=12.76, df=2, p=0.002$) more than younger participants. Younger participants were more likely to use YouTube for streaming ($X^2=17.17, df=2, p=0.028$). Notably, no significant difference was observed by age for the question asking about listening to owned music versus streaming unowned music, challenging presumptions that younger listeners are less concerned with owning music.

Our survey results indicated that, rather than age, gender seemed to play a larger role in cloud music behavioral differences. Almost half of the respondents reported using cloud services more than once a day, but men tended toward daily usage (90.7% of male users reported using cloud services ‘a few times a week’ or more), while women’s usage was much more evenly distributed between daily (‘more than once a day’ + ‘almost every day’: 36.4%), weekly (‘a few times a week’ + ‘about once a week’: 36.4%), or monthly (‘2 or 3 times a month’ + ‘once a month or less’: 27.3%) access and usage ($X^2=42.13, df=5, p=0.000$).

In general, we noted a trend across multiple questions indicating that women tended to listen to music within their collections and were less likely to listen to music they did not already know than men were. Nearly half of female participants noted that they ‘mostly’ (20.0%) or ‘almost always’ (27.3%) listened to music they owned, whereas almost half of male participants ‘mostly’ (30.7%) or ‘almost always’ (15.0%) streamed music ($X^2=15.05, df=5, p=0.010$). Women were far less likely to report that they used the services for listening to music they did not have in their collections (47.3% for women [W]; 79.3% for men [M]; $X^2=19.37, df=1, p=0.000$), and made far less use of cloud recommendation and discovery functions (36.4% for W; 77.1% for M; $X^2=29.12, df=1, p=0.000$), such as new music suggestions (29.1% for W; 47.1% for M; $X^2=5.28, df=1, p=0.02$), automatically generated playlists (38.2% for W; 69.3% for M; $X^2=15.99, df=1, p=0.000$), and suggestions from friends (12.7% for W; 28.6% for M; $X^2=5.42, df=1, p=0.020$), than men did. 38.2% of female respondents noted that they did not use cloud services for music discovery at all, compared with 19.3% of men ($X^2=7.60, df=1, p=0.006$). One possible caveat here is that women reported much higher usage of the Pandora streaming service alongside cloud services (70.4% for W; 45.4% for M; $X^2=9.56, df=1, p=0.002$). Pandora, an Internet radio service with personalization features, does not allow for collection building or search access to specific songs, and so may be a route to music discovery for some female users. However, it is possible that the heavier usage of Pandora among women may simply be an issue of convenience (Pandora requires no upkeep or maintenance once a station is chosen, unless the user decides to vote up or down songs she likes or dislikes). Women may also be using Pandora’s playlists for listening to similar songs (generated based on already familiar and preferred songs/artists) rather than seeking out channels playing new and unfamiliar music, or for listening to more mainstream genres, which they prefer more than men, according to Berkers [2]. Lastly, Pandora’s prominence among female users could merely be indicative of targeted advertising; it is mirrored in the site’s general user demographics.\(^1\)

Women reported using cloud services to purchase music more than men did (67.3% for W; 50.0% for M; $X^2=4.76, df=1, p=0.029$), but were much less likely to pay for the cloud service as a whole than men were (29.1% for W; 78.6% for M; $X^2=42.28, df=1, p=0.000$), both confirming and complicating Makkonen’s [20] finding that women express a higher willingness to pay for music albums and tracks. When asked how they initially found out about cloud music services, more males chose the options ‘I sought out cloud services to fit my music listening needs’ (32.7% for W; 53.6% for M; $X^2=6.877, df=1, p=0.009$) or ‘through an advertisement’ (9.1% for W; 24.3% for M; $X^2=5.70, df=1, p=0.017$), while women were more likely to choose the responses ‘the service was preinstalled on a device I obtained’ (45.5% for W; 12.9% for M; $X^2=24.41, df=1, p=0.000$) or ‘a company automatically signed me up for a cloud music service’ (30.9% for W; 5.0% for M; $X^2=24.56, df=1, p=0.000$). Perhaps not coincidentally, men were far more likely than women to report using Google Play Music though many women also used this service (45.5% for W; 82.9% for M; $X^2=27.59, df=1, p=0.000$), while women were much more likely to use Apple iCloud and very few men were iCloud users (54.5% for W; 12.1% for M; $X^2=38.81, df=1, p=0.000$). Apple tends to focus on integration of software and hardware, and frequently bundles services together.

This seems to indicate that women are exercising less overt consumer choice in selecting a cloud provider, which may have implications for service fit and user satisfaction. For instance, women were much more likely than men to use the services for transfer between devices (70.9% for W; 34.3% for M; $X^2=21.43, df=1, p=0.000$), and they were more likely to report problems with transferring files (47.6% for W; 15.4% for M; $X^2=9.95, df=1, p=0.002$) and device compatibility issues (23.8% for W; 6.4% for M; $X^2=5.52, df=1, p=0.019$) when asked about service deficiencies. Suki [29] reports a similar tendency of men having a higher level of perceived ease of use than women when using online music. Women have more music not uploaded to the cloud (76.4% for W; 49.3% for M; $X^2=11.50, df=1, p=0.001$) which may reflect that they have enough music in the cloud for their needs now (45.2% for W; 30.4% for M, although not significant) and that they prefer to listen to physical copies (35.7% for W; 18.8% for M; $X^2=3.941, df=1, p=0.047$).

4.7 Thoughts on the Trend of Moving to the Cloud

Our survey concluded with an open-ended question asking respondents to express other thoughts or opinions they had about cloud computing and cloud music storage. 98 users responded with statements of length varying from a single sentence fragment to several paragraphs. These responses were qualitatively coded and examined for common patterns using a consensus code strategy [11]. We found that the codebook developed for our interview project [17] was useful as a starting point, and only a few codes were added to this preexisting frame-

\(^1\) Alexa.com reports that Pandora’s userbase skews strongly female. http://www.alex.com/siteinfo/pandora.com
work during coding iterations. The most common topic which surfaced in these responses was the relationship between cloud and streaming music platforms and their relative benefits and drawbacks. Alongside this was an abiding concern over issues of ownership and access, present in nearly a quarter of responses. Users expressed keen and sometimes profuse opinions about ownership and access modes of listening, just as the interviewees did in our project’s first phase [17] - but without explicit prompting, and with minimal addressing of the topic in earlier survey questions (only one question, discussed in Section 4.4, indirectly references this issue). As in [17], participants expressed a variety of positions: one uneasy user noted, “The entire system of ‘owning music’ is nearly obsolete. The legal as well as social ramifications of identity ties to cultural objects to which someone else controls all access is little understood and downright frightening” (ID: 36), and another cloud skeptic stated, “It’s scary to think of everything being online without a physical copy anywhere. I still purchase CDs and import them to my online service because I enjoy having a real CD, but appreciate the probabilities of cloud streaming.” (ID: 110) Still others saw cloud-based access models as an nigh-unstoppable new wave: “These [record] labels need to wake up the internet/cloud is not a fad it is the future. SJure it will be improved upon but I have not bought a physical album in years and eventually no one will.” (ID: 311) Once again, age was not a reliable predictor of opinion on ownership/access matters; many under-26 users favored owning files, and several over-30 users favored access-only streaming systems. Concerns over service cost (22 responses), praise or circumpection regarding service convenience (20), opinions about artist and genre availability (15), and fears or experiences of network and data issues (20) and storage caps (15) also factored prominently into responses to this call for opinions.

One topic which was more prominent in our survey than the interviews was artist royalties, perhaps influenced by recent news coverage of court cases involving streaming royalty payments, as well as the weighing-in of high-profile musicians (such as country/pop superstar Taylor Swift) on the subject. Some wrote approvingly of service handling of royalty payments, such as the user who wrote, “I like the fact that the music is now more available to more people and that it can be accessed more globally while still generating revenue for the artist.” (ID: 101) Others had more ambivalent reactions: “While as a musician I recognize the damage s(t)reaming services [have done] to the industry, as a listener the convenience is absolutely incredible and has introduced me to so much new music.” (ID: 192) Also more prominent in survey responses than in the interviews were comments regarding audio quality of services; one user replied, “I would never consider going all-streaming, unless I (and the infrastructure) were able to do this with full-quality uncompressed audio... I'm interested in services like PONO and TIDAL with ‘high-quality’ audio streaming, but, they are too expensive for me to opt in.” (ID: 103)

5. CONCLUSION AND FUTURE WORK

Our survey results show that cloud music services are primarily used to improve music access by overcoming limitations imposed by device storage or lack of ownership. While listening from participants’ own music collections was the top usage of cloud services, streaming music they do not own was important as well. This seems to signal a desire for merged systems with both cloud and streaming features. The services are also used for music discovery and management, though less so for sharing music. Exploring and implementing better ways to share listening experiences may help improve users’ experiences with cloud services. Collection-building and streaming approaches divide online music usage, although there is a slight preference toward streaming.

Approximately half of participants reported choosing services to fit their needs, although a substantial number were influenced by preinstalled options, word of mouth, and advertising. Major contributing factors in user service choice included device compatibility, ease of upload, storage space, brand loyalty, price, and music availability. Over half of the participants indicated the desire to change something about the services they use. Again, the lack of good sharing features was the most commonly mentioned factor, followed by dissatisfaction regarding the design and functioning of the service. Difficulty transferring music was also mentioned by about a quarter of participants. Nearly half of respondents indicated they would consider switching to another service based on price, artist selection, and device compatibility.

Differences regarding use of cloud music services were much more prominent by gender rather than age. Women reported listening to music they owned more than men, sought out new music less than men, paid for services less often, and asserted less consumer choice in selecting services than men did. This warrants future investigation of the underlying reasons for these differences, and also suggests opportunities for developing music services tailored to gender-specific usage.

In future work, we plan to continue our investigation of music users, focusing on two aspects: 1) the meaning of personal collections in an increasingly streaming-dominated environment, and 2) investigation of reasons for the differences observed in music selection, listening, and sharing between genders.

6. ACKNOWLEDGEMENTS

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7. REFERENCES


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