Stay Tuned! An Investigation of Content Substitution, the Listener as Curator and Other Innovations in Broadcast Radio

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ABSTRACT

This paper demystifies listeners' wishes with respect to broadcast radio innovation (with a specific focus on radio-mediated music consumption). Our study encompasses an ideation workshop with radio experts, an exploratory survey and a mixed methods empirical evaluation. The empirical evaluation uses two concrete concepts (i.e., letting listeners *on-the-fly replace radio content with preferred content* and fostering participatory radio production by *involving listeners as radio content curators*) as a lens to zoom in on the questionable desirability of radio innovation. It is learned that a significant consumer group exists who will stay loyal to broadcast radio even if it does not evolve substantially, whereas others need disruptive incentives to start listening to radio (again). From our results we distill design recommendations to educate the radio production community about how best to approach radio innovation.

CCS CONCEPTS

• **Information systems** → **Multimedia streaming**; • **Human-centered computing** → Laboratory experiments; **User studies**.

KEYWORDS

linear radio; innovation; subjective evaluation; survey; behavior; personalization; privacy

1 INTRODUCTION

Broadcast radio, also referred to as *linear radio*, is a popular medium with a long history and a rich tradition. Important arguments in favor of radio's popularity are its pervasiveness and accessibility [37], the simplicity that stems from its lean back form of content consumption (e.g., no or little need for configuration) [57], the shared live experiences that it affords [2], and the fact that it provides audiences with a mix of music, news, information, entertainment and/or live event coverage [28]. Over the years however, broadcast radio started witnessing competition from many types of technological innovations. Prime historic examples of such contenders are storage media like audio cassettes and Compact Discs, television and video streaming, and digital media formats like MP3 [27]. Most recently, Social Media in general and music streaming services like Spotify and Apple Music in particular are battling broadcast radio for listeners' ears and attention [39]. In 2019, no less than 89% of the worldwide online population listened to music via on-demand streaming platforms [31].

All of the technological advancements that were referenced in the previous paragraph have in common that they afford people additional choice and control over their listening (and viewing) experience [32, 39]. Interestingly, this seems to have only a relatively modest impact on the popularity of broadcast radio among media consumers. For example, in 2018, 66% of the surveyed Canadian population discovered new music via the radio versus only 43% music discovery via streaming services [54]. When looking broader than purely music discovery and consumption, measurements by the European Broadcasting Union (EBU) show that, in 2018, 84.2% of the European population listened to broadcast radio on a weekly basis versus 85.9% in 2013; the daily radio listening time of European citizens equalled two hours and 22 minutes in 2018, down 14 minutes compared to five years earlier [19]. These EBU statistics indicate that, in recent years, radio's reach has remained rather stable in Europe, yet that the quantity of actual radio listening time is somewhat decreasing. Ironically, broadcast TV, whose introduction was expected to herald in the demise of radio, seems to be struggling much harder than radio in terms of both popularity and consumer-perceived relevance (i.e., the so-called cord-cutting behavior) [53].

Given that radio relatively succeeds in standing its ground in the contemporary media landscape, we pose the following research question: *does radio need to innovate or even reinvent itself in order to stay relevant in an era where consumers have grown accustomed to the flexibility and dynamism offered by music streaming platforms? If so, how and to what degree?* As a secondary research question, we are interested to know *to what degree radio innovation would lead to quantitative increases in radio listening time.* To address these questions, we apply a three-stage methodology (see Section 3) spanning an affinity diagramming workshop with domain experts, a survey targeting both radio makers and listeners, and a mixed methods empirical study of two radio innovation propositions. Both the survey and the empirical study explore, with different levels of detail, radio listeners' perception of (the added value of) innovative radio use cases and listening experiences; this exploration is situated at the conceptual rather than the technological level (i.e., without consideration for practical implementation and deployment). By pooling the results from the different parts of our methodology, we attain our primary contribution, which is a set of design recommendations for radio innovation (see Section 7). Our secondary research contributions are the following: (i) we shed light onto listeners' propensity towards different types of radio innovation, (ii) we reflect on the privacy implications of radio innovation, and (iii) we discuss the probability of people changing their radio listening habits (e.g., start to listen more to radio) as a result of radio innovation.

2 BACKGROUND AND RELATED WORK

Media experiences, including broadcast radio, are in a continual flux due to factors like technological advancements and evolving consumption habits. For example, everyday music listening has been found to show evermore complex patterns due to technology affording greater control to the listener and because of a shift in consumption behavior (i.e., from passive listening to active music consumption) [32, 39]. Another example is the surging popularity of mobile video consumption among millennials and teenagers [38]. This section will extensively yet concisely review the media experience innovations that jointly have shaped our work. Please note that our work is situated exclusively in an entertainment or leisure setting; radio consumption as part of professional scenarios (e.g., [25]) is out-of-scope. Also out-of-scope are technological innovations in the radio domain (e.g., DAB Multimedia Object Transfer [17] or RadioDNS [18]); as stated in Section 1, our work focuses exclusively on the conceptual rather than technological level.

A first relevant media innovation is *interactivity*. Aylett et al. have proposed a mobile interactive radio prototype that intertwines a user's personal music library with text-to-speech renditions of textual content like Facebook posts and news items [1]; thanks to its pervasive nature and its support for eyes-free interaction, the prototype is posited as a step towards realizing the calm computing vision proposed by Weiser and Brown [60]. Sappelli et al. have experimented with non-linear, interactive delivery of news items that have featured on broadcast radio; their prototype was positively received by listeners [48]. Bailer et al. have described high-level challenges but also opportunities for the cost-effective *authoring* of interactive radio content (e.g., summarization techniques) [2]. Claes

et al. have put forward five attention points concerning the design of interactive radio shows: facilitating listener feedback, content co-creation opportunities, personalized services for listeners, on-demand content consumption options, and nurturing community feeling [11]. Finally, *interactive narration techniques* are increasingly gaining traction in the context of over-the-top (OTT) video streaming (e.g., [36, 62]) and audio dramas (e.g., [14]). A prominent example is the interactive Bandersnatch episode of Netflix's Black Mirror series, in which the viewer (through interaction) can impact the direction of the narrative to yield a personalized viewing experience [47].

Next to interactivity, there exists a substantial body of research about *personalization* in the context of broadcast radio and musical experiences. Ben-Elazar et al. have looked at the personalization of musical playlists [4], while Ferwerda and Schedl have examined how to enhance music recommender systems with personality information and emotional states [20]. Odom and Duel have contributed the *OLO radio* design artifact that allows people to explore and (re-)experience the music that they have listened to over the course of their lives [42]. Turnbull et al. have found that personalized radio can help to stimulate the discovery of local music and local musical events [55]. Casagranda et al. have proposed *Hybrid Content Radio* (HCR), which combines linear radio with OTT delivery of personalized audio content [7]. In the HCR approach, parts of the radio broadcast are proactively replaced with relevant audio content based on numerous contextual factors. As part of their HCR research, Casagranda et al. have touched on radio innovation topics like *seamless handover between multiple radio listening devices* (see also [16]) and *temporal scaling of the duration of the replacement content* (see also [57]). Finally, Cowlishaw et al. have pointed out an ideological mismatch between personalization and Public Service Broadcasting (PSB), in that personalization challenges social cohesion and reduces output diversity, which are two core PSB values [15].

A potential technology to implement interactive and/or personalized media experiences is *Object-Based Media* (OBM). Instead of delivering pre-compiled experiences, the OBM paradigm streams *atomic objects* and associated metadata to the consumer so that media presentations can on-the-fly be assembled at consumption side. OBM is a relatively hot research topic in TV and video production (e.g., [34, 56, 61]) yet seems less successful in permeating the radio domain (e.g., [5, 7]).

Participatory production (i.e., when consumers are able to contribute to the media experience) is another rather recent phenomenon in the media landscape. Prime examples here include game live streaming (e.g., [40, 63]), crowdsourced video coverage of real-world events (e.g., [26, 58]) and co-creation of TV shows by means of user-generated video (e.g., [13]). With respect to participatory radio production, recent work has explored the (semi-)automatic handling of messages shared by listeners (spanning text, photos and videos) in order to improve storytelling in live radio shows [12]. A related concept is that of *community radio* (i.e., radio that is produced by, and for, members of a specific community), which has been studied in relation to, for example, civic engagement (e.g., [37, 45]) and information accessibility (e.g., [51]).

Finally, audio-based applications (including broadcast radio) are witnessing innovation attempts in terms of *analog-to-digital conversion* (e.g., [24]), *location-aware content consumption* (e.g., [35]), *hybrid delivery models* that combine the broadcast signal with a per-listener, non-linear OTT channel (e.g., the HCR approach), *listener notification* (e.g., [50]), the use of *chatbots* to automate textual interaction with listeners (e.g., [12]), the use of *voice interaction* and *smart speakers* (e.g., [8]), the use of synthetic voices in radio programmes (e.g., [51]), and *data-driven visualisations* like charts to graphically augment the audio signal (e.g., [3]).

It turns out that prior art fails to present a holistic view on radio innovation. This paper aims to fill this hiatus by exploring which actions radio must take (if any) to remain relevant in the evermore competitive media landscape.

3 METHOD

To address our research questions, we applied a tripartite methodology. The first methodological step consisted of an affinity diagramming workshop [29], with the goal of mustering input from domain experts about promising future radio functionality. All workshop participants were European citizens (8 male, 3 female) who are professionally involved in broadcast radio, yet in divergent roles and capacities (e.g., members of the R&D department of a public radio broadcaster, engineers of radio production software, a specialist in privacy and data protection in relation to broadcast radio). We deliberately chose to recruit radio experts (as opposed to listeners), as our goal was to let an educated group of people derive *themes* and *associated keywords* related to radio innovation based on their implicit knowledge of the state-of-the-art and upcoming trends in the radio domain. The workshop was conducted in October 2019, had a duration of approximately two hours, and was informed by the findings of our literature review (see Section 2). Due to space limitations, we will not elaborate on the details of this workshop, other than saying that it elicited expert suggestions to make radio listening more engaging (e.g., participatory radio production), more convenient (e.g., seamless handover between listening devices), or more functional (e.g., radio bookmarks). The workshop results drove the design of the second stage of our methodology, which was a digital survey (n=196) to explore listeners' opinion about promising radio innovation opportunities (see Section 4). Finally, based on the survey results, we implemented an empirical study (n=16) to drill down two potential avenues for innovative radio technology, namely *real-time content substitution* and *listener co-creation in radio production* (see Section 5). The three stages in our methodology apply an ascending level of detail (i.e., from the general to the concrete) and were all approved by the ethical committee of Hasselt University.

4 SURVEY ON "THE FUTURE OF RADIO"

Our affinity diagramming workshop yielded eight radio innovation themes (see the leftmost column of Table 1) and associated keywords. Based on this output, we designed a survey to explore people's propensity towards concrete radio innovation propositions. The eight workshop themes were each integrated in the survey by means of a series of mandatory multiple choice questions plus one optional open question; the open question allowed respondents to

freely elaborate their opinion on the theme. All multiple choice questions utilized a 5-point Likert answering scale (ranging from "strongly disagree" to "strongly agree", with a neutral midpoint). The exact formulation of the survey questions was iteratively derived based on feedback from pilot testers. This cyclic process was repeated until the pilot tester (a different person in each iteration) no longer had fundamental remarks about the contents of the survey. Three *gold standard questions* [30] were interwoven in the survey. These questions asked the respondent to select a predefined answer and were used as a screening mechanism to identify invalid responses. More precisely, a respondent was invalidated in case (s)he violated at least two of the three gold standard questions and did not fill out any of the optional open questions. The time needed to complete the survey was estimated to equal 20 minutes.

4.1 Dissemination and Participants

The survey was advertised via numerous channels like Social Media, mailing lists, printed posters and a website hosted by Belgian public broadcaster VRT. The survey was available during January and February 2020 and attracted 196 respondents. The screening procedure explained earlier revealed five untrustworthy respondents. The results communicated in the remainder of this section refer to the remaining 191 valid respondents (115 male, 76 female).

In terms of demographics, 115 respondents (i.e., 60.2%) were between 18 and 34 years old (with a nearly equal split between the 18-24 and 25-34 age ranges). Three respondents were younger than 18 years old, 26 were in the 35-44 age range, 17 were between 45 and 54 years old, 19 were between 55 and 64 years old, and 11 were 65 years or older. The respondent population includes 12 people who indicated to be involved in radio production, either professionally or as an enthusiast. 80.6% of the respondents claimed to listen to broadcast radio more than one day per month, with almost half of the respondents (i.e., 45.6%) claiming to listen at least five days per week. The majority of the respondents live in Belgium (i.e., 55%) and the Netherlands (i.e., 17%), yet the survey also reached respondents from 20 other countries including the United Kingdom, the USA, France, Germany and Turkey.

4.2 Analysis

To analyze the responses to the multiple choice questions, the Likert scale answers were numerically mapped to integer values ranging from one to five. To identify statistically significant differences between respondent subgroups (e.g., radio producers versus listeners), the non-parametric Mann-Whitney's U test was applied due to opinion scores being ordinal data and the independent measures experimental design. Similarly, when comparing between more than two respondent subgroups, the non-parametric Kruskal-Wallis test was used; in case this yielded a significant difference and a post-hoc test was needed, pairwise Mann-Whitney's U test s with Bonferroni corrections were calculated. Finally, the responses to the open questions were processed using thematic analysis [52]. The thematic analysis was performed by one researcher, whose findings were independently reviewed and amended by a second researcher.

Table 1: Quantitative survey data (mean ± standard deviation, max score = 5). Questions in bold are discussed in running text.

Theme	Question (discussed in running text if **in bold**)	Score
Personalization	Radio contributes more to community building and *group feeling* than music streaming services do	3.64 ± 0.99
	Sharing personal information with radio stations to enable personalization worries me w.r.t. privacy	3.12 ± 1.20
	I like the idea of alternative, simultaneously broadcast radio shows that cater to different audiences	3.74 ± 0.93
	Having access to a personalized playlist *with predefined duration* is valuable	3.62 ± 1.04
Multimedia and visual radio	**It would be nice to complement radio coverage of real-world events with relevant media (e.g., UGC)**	3.23 ± 1.02
	Sharing multimedia content with radio stations worries me in terms of privacy and data protection	3.06 ± 1.09
	Visual radio is a good platform to show photos/videos that listeners have shared with the radio station	3.41 ± 0.96
Influencing the musical playlist	**I'm afraid that personalization will make me miss out on (new) songs that fall outside my typical taste**	3.70 ± 1.06
	I'm willing to vote for my favorite song from a short list	3.52 ± 1.00
	I'm willing to give a *thumbs up* or *thumbs down* for the currently playing song	3.63 ± 1.07
Song substitution	**I like to be able to replace disliked songs with songs that I like (without affecting others' radio playback)**	3.64 ± 1.00
	Song substitution should be controlled manually (score of 1) versus automatically (score of 5)	2.70 ± 1.15
	It would be useful if non-musical radio items which don't interest me could be replaced with music	3.80 ± 1.06
Notification	I want to be notified when an item that is relevant to me personally is about to be played on the radio	3.13 ± 1.26
	I want to have the option to easily consume a radio item that is relevant to me in an on-demand fashion	3.92 ± 0.94
Bookmarking	Bookmarking functionality (as known from Web browsing) is useful in the context of broadcast radio	3.68 ± 0.95
	Being able to pause/resume/catch-up the live radio broadcast is a useful feature	4.05 ± 0.75
	Being able to share *specific parts* of a radio show with friends for on-demand consumption is useful	3.72 ± 0.90
Participatory radio production	**To me, broadcast radio consumption is a predominantly passive, *lean back* experience**	3.91 ± 0.86
	The more I can interact with the radio station (e.g., text messaging), the more *involved* or *engaged* I feel	2.78 ± 1.19
	I believe it is important that I can share my opinion with a radio station	2.92 ± 1.17
Location & travel	Being able to seamlessly switch between listening devices will keep me listening longer to radio	3.51 ± 1.05

4.3 Results

Table 1 shows a critical selection of quantitative survey results. For the sake of brevity, only the most relevant results are enumerated (i.e., the results for the survey questions that got the most extreme quantitative scores or for which sufficient qualitative context could be collected via responses to open questions). The reader is also advised that the quantitative data shown in Table 1 will only be selectively discussed in the remainder of this section and that no one-on-one mapping exists between the sub-headings of this section and the eight themes that emerged from our affinity diagramming workshop (which are shown in the leftmost column of Table 1). An interesting high-level finding of our survey is that comparisons between age groups did not yield noteworthy statistically significant differences.

4.3.1 Consumption flexibility. Of all explored radio innovations, respondents were most enthusiastic about the ability to "pause/resume/ catch-up the live radio broadcast" (average score of 4.05). Unfortunately, no qualitative data was submitted by any of the respondents to clarify their interpretation of such a feature or the demands they have for it. However, since the second highest scoring feature pertained to the on-demand consumption of radio content (average score of 3.92), it seems fair to conclude that users want radio consumption to be more flexible than just "listening live".

4.3.2 Radio Listening as a Side Activity. Another important quantitative observation is that listening to broadcast radio is typically seen by users as a passive, *lean back* experience (average score of 3.91). In addition, respondents had a less-than-neutral opinion on the two remaining questions pertaining to the **Participatory radio production** theme (see Table 1). This somewhat contradicts the findings from Krause et al. about active music consumption [32]

and seems to suggest that users perceive listening to respectively the radio and music rather distinctively. From the responses to the open questions, it becomes apparent that radio often plays a subsidiary role in people's everyday life. In particular, a total of 14 comments were captured mentioning that radio is about *"just listening"* and that it is a *"passive experience"*. In this context, several respondents mentioned that *"an important benefit of broadcast radio is that it requires less attention"*. One respondent mentioned that *"the 'just listening' part makes radio more intimate"*.

Listening to the radio while driving a car emerged as a spontaneous theme from the thematic analysis (i.e., it was not something that the questionnaire explicitly inquired about). This confirms that in-car listening is a highly relevant radio use case [7, 57]. The **Car driving** theme was linked to other surveyed themes, most notably **Notifications** (which need to be *"car-friendly"*), **Multimedia and visual radio** (*"when listening while driving, you cannot look at visuals"* and *"this seems dangerous with respect to road safety"*) and **Influencing the musical playlist** (*"not always feasible during car driving"* and *"I'm worried about the amount of attention this will require while driving"*).

Prior art has pointed to comparable findings in non-radio domains. For example, mobile video viewing was found to often occur in tandem with independent activities like cooking or while being in transit (e.g., for granting distraction or as "background noise") [38]. Similarly, people often listen to music while eating, exercising or driving their car [32, 59].

4.3.3 Multimedia and Visual Radio. The perceived passive nature of radio listening also had an impact on other topics, most notably **Multimedia and visual radio**. In particular, six respondents indicated that *"since radio does not require you to look but only to listen, you can be engaged in other activities like reading or working"*. That

being said, four respondents formulated comments on potential synergies between visual radio and Social Media. Two of these comments originated from radio makers, who respectively stated that *"visual radio is good for sharing highlights of the radio show on Social Media; it is more attractive to open the clip on Social Media if it includes video"* and that *"it might make sense to produce 'episodes' out of visual radio content which people can consume as a series (cf. TV shows) on YouTube"*. Finally, two respondents (of which one was a radio maker) thought that *"multimedia and visual radio work well in combination with special radio events"* like a Top-X hit list of the best songs of the past year.

4.3.4 Personalization of Radio Content. In general, the quantitative data pertaining to the **Personalization** theme as well as its related **Influencing the musical playlist** and **Song substitution** themes show slightly favorable inclinations among respondents. When comparing the responses to the questions in these themes based on respondents' (self-reported) daily usage of music streaming services, certain statistically significant differences emerged. In particular, the respondent population was divided into three disjoint subgroups whose daily listening time to music streaming services amounts to less than one hour, less than three hours and more than three hours, respectively. Based on this subdivision, the following five questions turned out to show a significant effect between respondent groups:

- offering alternative radio shows ($\chi^2(2) = 10.48$, $p < 0.01$),
- personal playlists with predefined duration ($\chi^2(2) = 9.81$, $p < 0.01$),
- vote for songs from a short list ($\chi^2(2) = 8.13$, $p < 0.05$),
- thumbs up/down for current song ($\chi^2(2) = 11.00$, $p < 0.01$),
- substitute disliked non-musical radio items with music ($\chi^2(2) = 15.17$, $p < 0.001$).

In all these cases, the post-hoc test identified statistically significant differences between the two extremes of the respondent subdivision, with the respondent subgroup consisting of the most avid music streamers consistently attaining the highest average scores. As an example, the largest difference between these two subgroups was reached for the question on using music to substitute non-musical radio items which are not of interest (average score 3.5 ± 1.07 versus 4.2 ± 0.79, p < 0.001). These statistically significant results seem to confirm that broadcast radio is indeed suffering fierce competition from music streaming services and that radio is failing to address the personalization needs that the fans of such services crave.

Proponents of personalization-related concepts mentioned potential advantages that personalization holds in the context of broadcast radio, including *"the ability to remedy the excessive airplay of popular songs"* and the observation that it *"could benefit listeners who are interested in less commercial music"*. However, the majority of the qualitative feedback was pejorative in nature and primarily pertained to the filter bubble effect [43] and the potential risks it entails in the context of broadcast radio. More specifically, nine respondents specified that *"personalization limits what you are aware of as well as your exposure to different and/or new things"*, whereas two respondents claimed that they wanted radio to *"surprise"* them. A directly proportional relationship was identified between (self-reported) radio listening frequencies and the Fear Of Missing Out (FOMO) effect with respect to potentially interesting music that

falls outside the listener's typical musical taste. In particular, users who reported to almost never listen to broadcast radio quantified this fear with an average score of 3.24 ± 1.16 versus 3.84 ± 1.02 for weekly radio listeners. This difference is statistically significant ($\chi^2(2) = 9.43$, $p < 0.01$ with the third respondent group being monthly radio listeners; the post-hoc test yielded $p < 0.05$).

4.3.5 Radio Makers Versus Listeners. The statistical analysis exposed three groups of significant differences between radio makers and listeners. Firstly, makers and listeners disagreed on the favorability of substituting a song with another song (mean rank of makers was 66.29 versus 97.99 for listeners; $U = 717.5$, $Z = -2.09$, $p < 0.05$, $r = 0.15$) and of using music to substitute disliked non-musical radio items (mean rank of makers was 62.17 versus 98.27 for listeners; $U = 668$, $Z = -2.31$, $p < 0.05$, $r = 0.17$). One radio producer contextualized these findings as follows: *"playlists are created with the most care by the musical director; they are part of the 'product' we want to 'sell' and broadcast"*. It hence seems that radio makers regard their profession as a form of craftsmanship that must be respected by listeners. Three listeners posted responses to open questions that agree with this craftsmanship perspective, yet such like-minded listeners were clearly a minority.

Radio makers also saw (even) more value in enriching radio shows that are tied to real-world events with event-related media (mean maker rank 125.79 versus 94.00 for listeners; $U = 1431.5$, $Z = 2.07$, $p < 0.05$, $r = 0.15$) and, interestingly, in on-demand radio consumption (mean ranks 124.79 versus 94.07; $U = 1419.5$, $Z = 2.02$, $p < 0.05$, $r = 0.15$). Regarding the latter topic, multiple radio makers provided qualitative feedback in which they suggested the exploitation of Social Media (see Section 4.3.3) or the conversion of radio items into podcasts as viable means to stimulate on-demand radio consumption.

Finally, radio makers' assumptions with respect to radio interaction were found to not necessarily match the expectations posed by listeners. In particular, the following statements triggered statistically significant differences, which might indicate that radio makers overvalue radio interaction opportunities:

- radio consumption is a predominantly passive experience (mean ranks of 58.3 and 98.5 for makers versus listeners)
- more interaction options lead to feeling more involved with radio (mean ranks of 133.17 and 93.51 for makers vs listeners)
- it is important that I can share my opinion with a radio station (mean ranks of 130.71 and 93.67 for makers versus listeners).

5 EMPIRICAL STUDY

Inspired by our survey results, we performed a subjective deep dive of two radio innovation opportunities, namely *radio content substitution* and *involving listeners as radio content curators*. The selection of these topics (at the expense of other radio innovation propositions that featured in our survey) is motivated by two arguments. Firstly, we wanted to investigate whether survey insights with respect to inter-theme popularity held true when themes are more profoundly evaluated by prospective consumers. To this end, we retained one theme that was positively received in the survey (i.e., **Song substitution** was among the highest scoring innovation areas, see Table 1) and one theme that mostly failed to convince survey respondents (i.e., **Participatory radio production**). Secondly,
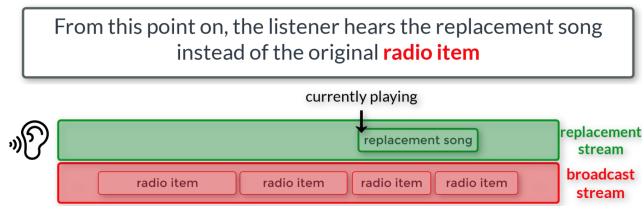
Figure 1: Conceptual visualisation of real-time substitution.

it was deemed interesting to study exactly these two themes, as they are rather perpendicular in terms of their impact on the radio listening experience; obviously, content substitution has a more disruptive impact in the context of broadcast radio consumption than co-creation has.

We approached the substitution concept as the ability to replace atomic items in the radio broadcast (e.g., an individual song, an interview, …) in real-time with another atomic piece of content (e.g., another song), with the listener automatically returning to the radio broadcast after the replacement content has finished playing (see Figure 1). Such substitution functionality operates on a per-listener basis, in that a substitution only disrupts the radio playback of a single listener (cf. HCR, see Section 2). On the other hand, the participatory radio production theme was framed as a *Listener-Curated Radio Show* (LCRS) where radio listeners can vote for their preferred songs within a specific musical niche (e.g., dubstep, synth-pop, death metal) and can optionally share spoken messages in which they motivate their choices or share a relevant anecdote. A produced LCRS program would then feature a musical playlist that is populated with the most popular songs (based on listeners' votes) and that is intertwined with relevant speech fragments submitted by listeners. Clearly, other ways to embody participatory radio production are conceivable, yet the LCRS approach was selected due to its simplicity and potential familiarity among listeners (e.g., radio shows already exist that run through lists of popular songs based on votes from their audience).

5.1 Experimental Design

The empirical study utilized a within subjects experimental design with individual sessions, meaning that each participant individually evaluated both investigated radio concepts. The presentation order of the two concepts was counterbalanced across participants. The user study was carried out in a dedicated room. A research facilitator accompanied the participant for the entire duration of the experiment.

The two concepts were introduced to participants via a combination of textual descriptions and illustrative videos (see Figure 1 and the supplemental material). The supporting videos of the substitution concept used animated visuals in combination with mocked prototypical radio content (i.e., a song followed by a discussion of a news item) and a replacement song that was auditively clearly distinguishable from the mocked radio broadcast. The LCRS concept on the other hand was evaluated by participants based on an annotated screencast of a high-fidelity prototype of a LCRS voting app. We deliberately did not let participants test prototype implementations of the studied concepts (even though such implementations

are actually available) as this would increase the probability of eliciting usability-related feedback, which was not the objective of the study. Instead, the study aimed to muster subjective data on the conceptual value, perceived usefulness and design options of the two investigated topics. A similar approach has been applied, for example, by Gravier et al. in their study on multimedia analytics [25].

Participants evaluated both concepts by filling out a digital questionnaire consisting exclusively of multiple choice questions. The majority of these questions utilized a 5-point Likert answering scale ranging from "strongly disagree" to "strongly agree". Seven multiple choice questions appeared in the evaluation of both concepts (see Table 3). Among these recurring questions were the well-known Single Ease Question (SEQ), which queries task-level satisfaction, and the two System Usability Scale (SUS) questions pertaining to frequency of use and learnability [49]. The facilitator kept track of the participant's progress in the questionnaires via screen sharing, so that (s)he could ask follow-up questions based on the participant's questionnaire input (cf. a semi-structured interview [33]). Once both concepts had been evaluated, the participant was requested to compare them with respect to overall value as well as potential privacy concerns. On average, it took participants 76 ± 21 minutes to complete the study; this time was roughly equally divided among both studied concepts.

In terms of analysis, the answers to the multiple choice questions were converted to numerical scores analogous to the approach described in Section 4.2. The opinion scores for the seven recurring questions were tested for statistically significant differences via a Wilcoxon signed-rank test (due to the repeated measures experimental design). Finally, the responses to the follow-up questions were transcribed and thematically analyzed (cf. again Section 4.2).

5.2 Participants

Via convenience and snowball sampling, 16 people (11 male, 5 female) were recruited to participate voluntarily in the study in March 2020. Participants were between 18 and 64 years old (18-24 age range: three participants, 25-34: six, 35-44: four, 45-54: one, 55-64: two). All participants live in Belgium and have diverse professions (e.g., computer science, education, logistics, sales, accounting). Regarding their frequency of listening to broadcast radio, 14 participants indicated to listen at least once per week; eight of these 14 participants even reported to listen more than five days per week. One participant claimed to (almost) never listen to radio and one participant listened less than one day per week. 15 participants reported to never interact with broadcast radio, with the final participant indicating a less than monthly interaction rate. Finally, our participants listen slightly more to music streaming services than to broadcast radio (average score 4.5 ± 1.79 on 7-point rating scale with 1 denoting "I only listen to broadcast radio" and 7 denoting "I only listen to music streaming services").

5.3 Real-time Substitution of Radio Content

A first quantitative finding is that the content that is used to replace broadcast radio items must not necessarily align perfectly with the preferences of the involved listener (see Table 2). This finding is also reflected in the qualitative data, where a clear split

Table 2: Study data (mean ± standard deviation, max score = 5). Questions in bold are discussed in running text in listing order.

Concept	Question (discussed in running text if **in bold**)	Score
Substitution	**How accurately must replacement songs follow musical preferences (5 = perfect accuracy)**	3.69 ± 1.01
	I want to be able to dynamically choose the source(s) and/or services from where replacement songs are taken	3.88 ± 1.09
	Radio items should be replaced with other items of the same type (e.g., replace a song only with another song)	1.50 ± 1.03
	Substitution of radio content should be controlled manually (score of 1) versus automatically (score of 5)	2.19 ± 0.98
	Adequate feedback is needed to inform the listener when an *automatic* substitution takes place	4.19 ± 1.33
	Having the option to substitute radio content would make me listen more to broadcast radio than I currently do	3.31 ± 1.20
	The more I would use the substitution concept, the more I would feel detached from other radio listeners	2.44 ± 1.26
LCRS	**Having the option to attach a speech fragment to a song selection is valuable**	2.50 ± 1.15
	How frequently do you envision yourself attaching a speech fragment to your song selections	1.25 ± 0.77
	How frequently would you like to hear speech fragments from voters (1 = never, 5 = at least one per song)	2.38 ± 1.26
	To what degree do you consider the tested LCRS concept to be a form of participatory radio production	4.00 ± 1.15
	If a radio station would deploy the LCRS concept, I would feel more *involved* or *engaged* with that radio station	2.88 ± 1.36
	The LCRS concept holds opportunities with respect to community building	3.38 ± 0.89
	I would like to have the option to consume LCRS radio shows in an on-demand fashion	4.25 ± 1.06
	I like the idea of alternative, simultaneously broadcast LCRS shows that cater to different target audiences	4.50 ± 0.82
	Overall, a produced LCRS radio show for a musical genre that I like, is something that I would want to listen to	4.31 ± 0.60

was noticeable between participants who desired maximal probability that the replacement content would be to their liking versus participants who tolerated room for serendipity and surprising replacement choices [22]. The participants in the former category commented, for example, that *"the content that is played must not get worse"* [P01, P09, P10, P12, P16] and that *"hearing replacement content which I don't like is more frustrating than just keeping on listening to the broadcast stream"* [P06]. Participants who leaned more towards serendipitous replacements did so because *"you can always initiate another substitution in case you do not like the replacement content"* [P01, P02, P08, P11] and because they want to *"get to know new music when listening to the radio"* [P03, P07]. Two of the participants who argued for the ability to initiate substitutions in reaction to an earlier substitution (i.e., P02 and P11) proposed that such follow-up substitutions should deliver more personalized content so that there is a higher probability that it will be to the listener's liking.

Participants slightly agreed that the provenance of the replacement content must be dynamically configurable (average score 3.88). It was mentioned that *"choosing the source of the replacement content based on my current mood makes sense"* [P02, P06, P09, P11] and that such configurability would be *"useful when listening to radio in group settings"* [P05, P06, P11] (i.e., influence the type of replacement content that you get based on the composition of a group co-located listeners). Interestingly, P05 and P11 gave exactly the same example of a group setting that would benefit from configurable sources of replacement content, namely that of parents who are listening to broadcast radio together with their (young) children.

There was consensus among participants that it should be possible to substitute *any* type of broadcast radio content (music, interviews, news bulletins, advertisements, …). Similarly, participants agreed that all sorts of radio content could serve as replacement material. Participants also suggested the use of non-radio content as replacement material, most notably podcasts [P01, P04, P06, P07, P13]. Finally, participants were adamant that the replacement of

radio content must not be confined to content of the same type (e.g., replace an interview with a song). With respect to non-musical content like news bulletins and traffic information, some participants suggested to *"use it as replacement content only in case the listener hasn't heard it already"* [P05, P08, P12]. Finally, P02 and P11 remarked that *"the user interface would likely become more complicated in case diverse content types could act as replacement material"*.

Concerning manual versus automatic substitution of radio content, participants leaned slightly more towards manual control than the survey respondents did (see Table 1 and Table 2). Participants identified various challenges with respect to automatically initiated substitutions: *"the system must not replace content which I would actually like to listen to"* [P01], *"mood dependency"* [P06, P10] (i.e., how to infer the listener's current mood, given that mood might impact what the listener wants to listen to) and *"incompatibility with listening to radio with a group of people"* [P12]. Very similar findings have been put forward by Geerts et al. in their recent empirical study on personalized video experiences [23], which shows that consumers' reservations against automated personalization crosses media boundaries. Also in line with [23] was the perceived need for listener feedback in the case of automatic substitution: *"you need to know that an automatic substitution has taken place and that you are listening to replacement content"* [P01-P04, P06, P09, P11-P14]. Auditory feedback was considered to be the most suitable solution, given that the use of other modalities would impose the need for additional or more advanced output devices.

Participants had a somewhat neutral opinion about the impact of the real-time substitution concept on their time spent on listening to broadcast radio (average score 3.31). The qualitative data revealed that the majority of the participants have a rather fixed radio listening schedule. Although most of the participants welcomed the real-time substitution concept, they estimated that it would not cause them to significantly alter their radio listening habits.

Participants were not convinced that substitution frequency would affect their feeling of being connected to other listeners.

Whereas a few participants confirmed that the real-time substitution concept would *"make it harder to talk to other listeners about radio content, given that not everyone would hear the same things anymore"* [P03, P05, P12], the bulk of the participants admitted that they *"have no sense of belonging to a radio community"* [P01], *"do not feel connected to other radio listeners"* [P04, P07, P08, P10, P12, P14-P16] or *"do not care about detachment from other listeners"* [P09, P11].

Finally, participants compared alternative designs concerning the transition from broadcast stream to replacement content and vice versa. Study participants largely agreed that the transition from broadcast stream to replacement content must happen as soon as possible after the intention to initiate a substitution has manifested itself (either manually by the listener or automatically). The transition from replacement content back to the radio broadcast was much more controversial. In the ideal scenario, replacement content has the same duration as (the remainder of) the substituted radio item. Indeed, this would allow for a seamless switchover where the listener can finish listening to the replacement content and can then hear the follow-up radio item from the very beginning. This scenario is however hard to realize in practice as it severely limits the pool of potential replacement material (especially when considering personalized replacements). Therefore, study participants were asked to rank, in terms of preferred listening experience, three realistic scenarios (illustrated in Figure 2) where the duration of respectively the replacement content and the radio item that it replaces does not match. There was no clear winner among these design alternatives in the quantitative data: the average scores of OPTIONs A, B and C equalled 1.94 ± 0.85, 1.81 ± 0.83 and 2.25 ± 0.77, respectively (numerical mapping, with a score of three representing the most preferred scenario). The qualitative data showed similar mixed reactions. OPTION A was criticized because *"listeners will hear part of the radio item that they substituted away (and they don't want to hear that content)"* [P08, P11, P15]. On the positive side, OPTION A guarantees that *"you will hear the next radio item from the start"* [P06, P09, P14]. Participants who favored OPTION B mentioned that *"I want my replacement content to finish because I explicitly chose for this content"* [P01, P02, P04]. Because of this, P01 and P07 thought that OPTION B was a good fit when using podcasts as replacement content, because *"a podcast must always play integrally"*. A recurring negative comment with respect to OPTION B is that *"you will miss the beginning of the next radio item"* [P02, P03, P05]. To tackle this deficit, P08 suggested to apply time-shifted playback of the broadcast stream (starting from the follow-up radio item) as soon as the replacement material has played fully. Finally, two proponents of OPTION C formulated their preference as follows: *"when I turn on the radio, I do it because I want to listen to it; so I want to hear the broadcast stream as much as possible"* [P09, P11]. When comparing OPTION B against OPTION C, 10 participants stated that their preferred transitioning mechanism *"very much depends on the follow-up radio item"*. For almost half the participant sample, integrally playing the replacement content (i.e., OPTION B) was found to be *"typically OK if the follow-up radio item is a song"* [P01, P02, P07-P09, P12, P14]. P03 and P06 fundamentally disagreed with this view in that they *"always want to hear songs in their entirety"*. Finally, exactly 50% of the participants preferred to prematurely end the replacement content (i.e., OPTION C) in case

the follow-up radio item is something other than a song (because they do not want to miss the start of non-musical radio items). Clearly, further research on this topic is needed (and also on the associated topic of temporal scaling of radio content [7, 57]). For the time being, it seems advisable to make the transitioning mechanism configurable by listeners.

5.4 Listener-Curated Radio Show (LCRS)

A first important quantitative result (see Table 2) is that participants somewhat contested the added value of attaching speech fragments to song selections, even though this is by far the most innovative component of the LCRS concept. Similarly, participants did not want the musical playlist of LCRS shows to be interwoven with too many speech fragments. The most notable negative remarks in this regard were that *"I don't feel the need to appear on the radio with my voice"* [P02, P04], that *"submitted speech fragments will need to be manually validated which will have an impact on production overhead"* [P05, P11], and that *"speech fragments will typically only be fun to hear for the involved listener and his/her friends"* [P05]. On the positive side, P01 mentioned that *"it can be funny to hear comments from listeners on the radio"*, P08 thought that the speech fragments *"allow for the sharing of feel-good stories on the radio"*, and P03 even went as far as saying that *"if I would listen to LCRS radio shows, I would do it specifically for the speech fragments"*. Participants also proposed approaches other than speech to motivate their song selections. By far the most popular suggestion was the use of textual messages, which *"a radio DJ could read aloud"* [P01, P06, P07, P14] or which *"could be shown in a second screen app"* [P11]. P11 and P12 proposed to annotate song selections with pictures (e.g., *"upload a photo that you took at a concert when voting for that artist or band"*).

When asked whether the LCRS concept is a form of participatory radio production, only P01 and P16 structurally disagreed because *"LCRS does not go far enough to be really considered participatory"* and because *"you have too little control [over the final contents of LCRS shows]"*. Conversely, P07 and P13 classified LCRS as *"a perfect example of participatory radio production"*. P02, P04 and P09 stated that LCRS *"democratizes radio, since you can pick your own music"* and P06 thought that it allows listeners to *"share their preferences and opinions with other people"*. P03, P11 and P12 considered the LCRS concept to be participatory chiefly due to the ability to submit speech fragments.

Participants slightly disagreed that the LCRS concept enhances engagement with broadcast radio (average score 2.88). This quantitative finding is partly caused by the fact that many participants indicated that *"a LCRS radio show is something that I would want to listen to, but not necessarily contribute to by voting for songs"* [P01, P03, P07, P13] or that they are *"not interested in radio engagement at all"* [P09]. Somewhat similarly, nine participants agreed that LCRS unlocks options concerning community building (e.g., *"you get a sense of community among voters"* [P07]), yet five of these participants explicitly indicated not to be interested in the radio community nor community building in general. P07 suggested to include gamification concepts [46] like *achievements*, *badges* and *leaderboards* to allow listeners to distinguish and advertise themselves in the LCRS community. In general, while our qualitative data does seem to suggest that LCRS holds power with respect to
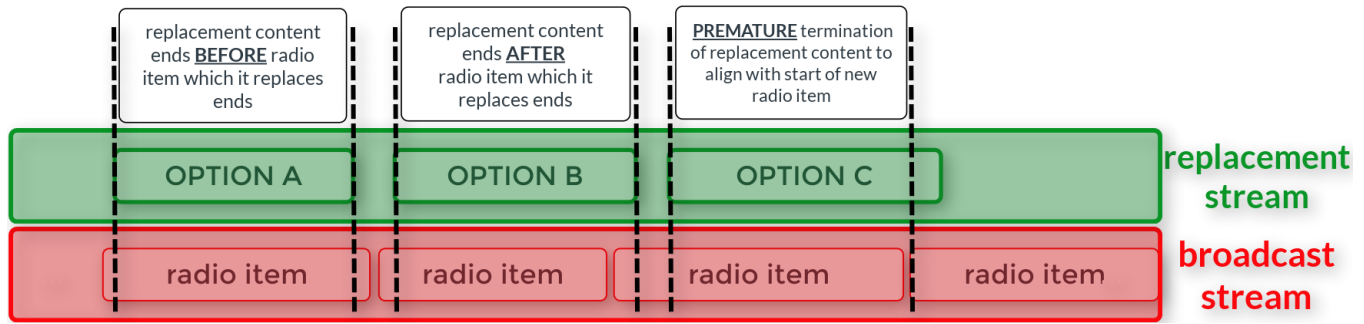
Figure 2: Transitioning options from replacement content back to broadcast stream.

nurturing community feeling (cf. [11]), it is doubtful whether this suffices for the format to be perceived by listeners as a fully fledged form of community radio (cf. [37, 45]).

Having the option to consume LCRS radio shows in an on-demand fashion was greatly welcomed by participants (average score 4.25). Participants suggested several potential avenues to implement such on-demand consumption: conversion to playlists for music streaming services (with the resulting playlist holding only the selected songs and not the aired speech fragments), integration in the client-side app that you use to contribute to LCRS production, via the radio station's website, or as a podcast that you can listen to using traditional podcast players. P08, P09 and P16 explicitly mentioned that on-demand consumption options would allow them to listen to LCRS radio shows while car driving.

Finally, participants were very enthusiastic about having the option to choose between alternative LCRS shows which are broadcast simultaneously yet target a different musical genre (average score 4.50). Several participants mentioned that such parallelism is *"a good solution in case you're not a fan of some of the alternative musical genres"* [P02, P04, P06, P09, P12] and that it *"allows you to choose what you want to listen to based on your present mood and preferences"* [P05, P06]. Participants also saw a benefit for radio stations, since *"it might prevent radio stations from losing listeners [who will switch to another station in case they do not like the targeted musical genre]"* [P04, P07, P08, P12]. In this context, P12 suggested that *"instead of opting for parallel LCRS radio shows, a radio station could opt for scheduling a LCRS radio show next to a traditional radio show"*. Finally, P01, P07 and P11 considered the idea of parallel LCRS shows to be *"a combination of the two tested concepts"*, in that it applies the real-time substitution concept to integral community-driven radio shows.

5.5 Concept Comparison

Comparative statistics for the two studied concepts are summarized in Table 3. The data shows that the real-time substitution concept attained a higher average score than LCRS when it comes to initial impression (i.e., as assessed immediately after each concept was introduced to the participant and before more focused questions were asked). This difference is statistically significant (Wilcoxon signed-rank test ; $W = 48.5$, $Z = 2.41$, $p < 0.05$, $r = 0.43$). Both concepts were deemed easy to use (i.e., average scores of (almost) six on the 7-point SEQ rating scale with 1 denoting "very difficult" and 7

Table 3: Concept comparison based on overlapping questions (mean ± stdev); statistically significant differences are marked in gray.

Question	Score (mean ± stdev)	
	Substitution	LCRS
Initial feeling about concept	4.31 ± 1.01	3.38 ± 1.15
How difficult or easy to use (SEQ)	6.00 ± 1.26	5.94 ± 0.93
Impact on radio attractiveness	4.00 ± 0.89	3.69 ± 1.08
Expected usage frequency (SUS)	3.81 ± 1.22	3.06 ± 1.00
Learnability assessment (SUS)	4.63 ± 0.50	4.50 ± 0.52
Suitability of voice interaction	4.06 ± 1.06	2.56 ± 1.21
Is worrisome in terms of privacy	2.19 ± 1.05	2.50 ± 1.03

denoting "very easy"). In terms of positive impact on the attractiveness of broadcast radio, expected usage frequency and learnability, the substitution concept attained slightly higher average scores; none of these differences are statistically significant.

Voice interaction was found to be a better match for the real-time substitution concept in a statistically significantly manner (Wilcoxon signed-rank test ; $W = 75.5$, $Z = 2.96$, $p < 0.01$, $r = 0.52$). This finding is in line with the perceived usefulness of voice-controlled content skipping in recommender systems [8]. For both tested concepts, voice interaction was deemed useful in situations where the user cannot use her hands to interact, most notably during car driving. In relation to the real-time substitution concept, it was remarked that *"voice interaction could allow users to express, in a natural and easy way, the source from where replacement content should be taken plus the type of replacement content that the user would like to get"* [P06, P08, P11] (e.g., "replace with podcast" versus "replace with rock song"). With respect to the LCRS concept, P04 commented that *"if I could vote for songs with my voice, I might submit more speech fragments, as I'm already using my voice to interact"*.

Finally, on average, the LCRS concept was interpreted to be slightly more worrisome in terms of privacy, yet this finding is not statistically significant. For the substitution concept, participants mostly identified privacy implications in case the substitution is controlled automatically, because such functionality would require *"a profile of your listening preferences"* [P02, P05, P06]. Participants

did not really see privacy-related differences based on the type of radio content that is substituted (e.g., a song versus a political interview). For the LCRS concept, the inclusion of the speech fragments turned out to be most problematic in terms of privacy [P04-P06, P10, P11]. As an example, both P06 and P11 were worried that the radio station might use their speech fragments for purposes other than just producing LCRS radio shows, while P04 disliked that speech input might be used for training speech recognition algorithms. However, overall, participants largely agreed that their privacy concerns about both tested concepts were limited, primarily because the data that they would expose was not deemed to be very sensitive.

6 DISCUSSION

Jointly, our survey and empirical study have examined (at ascending levels of detail) multiple opportunities with respect to radio innovation. The survey, which reached mostly radio listeners but also radio makers, was widely scoped and hence more exploratory in nature. As such, the survey looked at radio consumption and radio innovation from a relatively high level of abstraction. Then, in our empirical study, we performed an in-depth evaluation of two of the surveyed concepts and explored their design space as well as potential avenues for their practical implementation. The two tested radio concepts are readily realizable using contemporary technology yet were evaluated using mock-ups and illustrative videos because we wanted participants to reason about them on a conceptual level rather than performing usability testing. The biggest design uncertainty turned out to be the transition mechanism from the broadcast stream to replacement content (and vice versa) in the substitution concept (see Section 5.3); empirical follow-up research on this topic is advisable.

The empirical study has revealed an obvious winner, in that participants were clearly more enthusiastic about the real-time substitution concept compared to the LCRS idea (see Table 3). Additional evidence in this regard is that real-time substitution received 11 votes versus only five for LCRS when participants were explicitly asked to pick their favorite out of the two studied concepts. As such, the survey and empirical study agree on the difference in potential between real-time substitution and participatory radio production (with the latter being embodied in the form of LCRS in our deep dive). That being said, the empirical study has also revealed that participants had a somewhat neutral opinion about the ability of the "winning" substitution concept to convince them to listen more to broadcast radio, which is likely to be a crucial metric for radio stations investing in innovation. A recent exploratory study on the (interactive) consumption of radio content on smart speakers [8] yielded a similarly counter-intuitive conclusion (i.e., the idea is generally well-received by study participants and its usefulness is acknowledged, yet this will probably not lead to increased radio listening times). A contextualization of this behavioral finding is given by the qualitative data collected as part of primarily our empirical study but also our survey, which will be discussed in the remainder of this section together with other key insights.

6.1 Key Insights

6.1.1 Know Your Listener. Our qualitative data proves the existence of a group of listeners who appreciate broadcast radio for what it is, despite its "shortcomings" and its lower degree of flexibility when compared to other media platforms like music streaming services. This is evidenced by statements like *"the power of radio is precisely that you can listen to radio shows that have been carefully curated by radio professionals"* [survey], *"when I turn on the radio, I'm making a deliberate decision to listen to the radio and not to a music streaming service"* [P03], and *"replacement content might clash with the identity of the radio station"* [P02]. Similar observations have been put forward in prior art (e.g., [11]). This consumer group of "radio loyalists" not necessarily wants broadcast radio to innovate itself, given that they value the passive yet carefully curated listening experiences that radio has been delivering ever since the conception of the medium. Stated differently, these listeners primarily want radio to keep on doing what it is doing now, potentially combined with gentle evolution but not revolution. Our survey results show that *consumption flexibility* (e.g., in the form of bookmarking functionality or on-demand listening options) is a good example of a desirable evolution for this user profile. Our qualitative data additionally reveals that this type of consumer typically either already listens to broadcast radio a lot or has rather rigid radio listening patterns, and that neither the real-time substitution functionality nor the LCRS concept would be capable of affecting their radio listening times and routines. A field trial would be needed to confirm or reject the validity of these self-assessments.

At the other end of the spectrum, there are people who fundamentally dislike some of the underlying principles of linear radio like, for example, the fact that it is a broadcast medium and hence inherently is geared towards entire listener populations instead of individual consumers. For this category of listeners (e.g., music streaming aficionados), statistical analysis of the survey data has clarified that *consumption freedom* and *agency* are paramount (e.g., choosing between parallel radio shows, having access to personalized playlists). Our empirical results additionally show that the two studied concepts are insufficiently interesting or innovative for this user category, with LCRS being clearly less so compared to real-time substitution . In effect, P01 saw LCRS as a *"less personalized version of real-time substitution "*, whereas other participants discerned *"conceptual overlaps between LCRS and music streaming services"* [P02, P08, P12, P13], however with the latter by far being their preferred option. To make the LCRS concept more attractive and engaging for this customer profile, the integration of a Conversational User Interface (CUI) and/or collaborative or even competitive elements could be investigated [13]. To end on a positive note, certain music streaming lovers in the participant sample postulated that the tested real-time substitution approach could remedy parts of their frustrations with radio and that this in turn could increase the probability of them (keeping on) listening to radio: *"once I switch from radio to music streaming, I typically will not switch back during that listening session; having the option to substitute radio content is a possible approach to postpone this switch"* [P01, P03, P04, P12].

Prevailing radio consumption statistics (e.g., [19]) confirm that the critical mass of the "radio loyalist" customer profile is still

sufficiently large. At the same time, recent research demonstrates that millennials perceive digital radio services (e.g., radio stations' smartphone apps) as different from music streaming services [9]. Combined with our own key insights, these observations cause us to conclude that radio must not blindly pursue innovation (e.g., by copying over music streaming features). Instead, radio must keep playing to its core strengths so as to keep its traditional consumers satisfied, and must combine this with targeted innovations that either cater to traditional consumers or try to (re-)attract radio-critical consumers to the medium.

6.1.2   Privacy and Data Protection. Both our survey and empirical study have looked at potential privacy implications of the investigated radio innovations. Interestingly, the empirical study yielded lower scores with respect to privacy issues compared to the survey. A potential explanation is that study participants visited the tested concepts in more depth, which might have triggered their (quantitative) assessments of privacy implications to be more behaviorally accurate (cf. the privacy paradox phenomenon [41]). From the qualitative data of the empirical study, it is learned that the personal data that needs to be exposed to enable the investigated concepts was generally deemed to be not overly sensitive; this is in line with the finding by Casagranda et al. that users generally agree to share their listening history in order to enable personalized listening experiences [7]. Some study participants also (correctly) deduced that they are already sharing their personal data as part of other services they use: *"this [substitution concept] would not disclose (much) additional information compared to what Spotify already knows about me, so this is not really a problem for me"* [P04, P07, P12, P14]. Finally, a considerable subset of study participants (i.e., P01, P03, P07, P08, P15, P16) in general did not care too much for privacy, aptly formulated by P01 as follows: *"convenience overrules privacy"* (cf. [44]). So, generally speaking, in both the survey and the empirical study, people's privacy concerns were relatively low and it seems like listeners are willing to share their personal information and sacrifice some of their privacy if doing so would lead to better radio experiences. Interestingly, in their study about TV and video innovation, Geerts et al. have identified more prominent privacy concerns [23]. As such, investigating potential differences in the perception of privacy implications in respectively the radio and the TV or video domain could be a valuable avenue for follow-up research.

6.1.3   Radio Makers versus Listeners. Our survey results have uncovered differences in the opinions of respectively radio makers and listeners with respect to the strengths of radio as well as its future. Most prominently, radio makers might attach too much importance to listeners' interaction opportunities (see Section 4.3.5). Listeners see broadcast radio as a predominantly passive medium (see Section 4.3.2) and might not engage that frequently in radio interaction (see Section 5.2 and also the limited interest in LCRS song voting, let alone in attaching speech fragments to votes). A similar finding was put forward by Claes et al. [11]. As such, our work informs radio makers about how best to align their radio shows with the expectations of listeners and about which radio innovation avenues are likely to yield maximal listener acceptance.

6.1.4   Accessibility. Radio's predominantly passive nature (see Section 4.3.2) and relatively limited innovation rate (see Section 2) have a positive effect on accessibility, which is known to be an important strength of the radio medium [37]. Radio playback devices are very widespread, including in cars, which helps to explain the popularity of listening to the radio while car driving. As the adoption of in-car smartphone integration frameworks like Android Auto or Apple CarPlay increases in the future, it will be very interesting to see whether music streaming services will be able to push back the popularity of in-car radio listening.

6.1.5   (Optional) Personalization. Throughout all stages of our study, personalization opportunities resonated particularly well with our participant samples. Personalization might actually hold the power to improve the appeal of broadcast radio for both listener profiles discussed in Section 6.1.1. The real-time substitution concept is a marked example of this: people who want to stay true to the traditional radio experience can decide to not use it (or only occasionally), whereas others are free to substitute radio content as frequently as they want to keep radio interesting to them. Furthermore, if personalization opportunities are made optional, they do not break the zero-configuration premise of radio [57] and in addition might allow users to dynamically switch between a traditional, *lean back* radio experience and a more innovative, *lean forward* type of radio consumption. Whether optional or not, radio personalization approaches must be wary of the filter bubble effect [43] and instead should consider the option of serendipitous content discovery (see Section 5.3). Our qualitative results concerning automatic substitution of radio content (see Section 5.3) also confirm the finding by Geerts et al. that personalization systems must grant their users insight into how and why choices were made and must allow quick user intervention in case personalization decisions turn out to be flawed [23]. Finally, it is important to be mindful that any type of personalization holds privacy hazards (see Section 6.1.2).

6.2   Limitations

A prototypical challenge with subjective research like the one presented in this paper, is the size of the participant sample and the degree to which results can be generalized. To boost survey participation, we could have resorted to crowdsourcing platforms, yet decided not to do so as it is known that crowdtesting is prone to yielding untrustworthy survey respondents (e.g., [10, 21]). With respect to our empirical study, it is common for these types of studies to have a smaller participant sample because of the focus on qualitative rather than quantitative results [6]. Perhaps more important than their cardinality is the degree to which participant samples are representative. The participants of the affinity diagramming workshop (see Section 3) were all professionals active in the radio domain. The radio listening frequencies of both our survey and study participants are roughly in line with recent European statistics (see Section 4.1 and Section 5.2). Also, the age range distribution of the participant samples of respectively the survey and empirical study are comparable and both samples include not only die-hard radio listeners or die-hard music streamers, but also people who split their listening time over radio and music streaming. As such, we believe that these participant samples are representative of contemporary radio and music consumers, most notably European

ones. Indeed, a limitation of our work is that it is European-centric (all participants of the workshop, 87% of survey participants and all study participants were European citizens) so it remains to be seen how well our results can be geographically extrapolated beyond Europe. Another limitation is that the nonadult age group (i.e., younger than 18 years old) is underrepresented in our study. For the adult respondents of our survey, age did not have a statistically significant impact on the results. Follow-up research that focuses specifically on teenagers seems advocated (e.g., to investigate potential discrepancies between minors and adults). A third and final limitation is that, while our work has revealed numerous innovation opportunities for broadcast radio, only two such concepts have been subjected to in-depth evaluation. If other concepts would have been selected for conducting an empirical study, the key insights would most likely be comparable, yet different emphases might have emerged. The reader is advised to take these limitations into consideration when interpreting our design recommendations which will be presented in the following Section.

7 CONCLUSIONS AND DESIGN RECOMMENDATIONS FOR RADIO INNOVATION

The holistic insights provided by merging the results of our survey and empirical study show that broadcast radio not necessarily needs to reinvent itself. A considerable quantity of listeners exists who appreciate radio for what it is, value its "human touch" and the feeling of intimacy that this evokes, praise the storytelling potential of the medium, and respect the craftsmanship of radio production. These users will likely keep on listening avidly to broadcast radio even if it would not change fundamentally in the future. On the other hand, our results also indicate that broadcast radio will have to work hard if it wants to (partly) win back some of the listeners that it has lost to music streaming services. The real-time substitution of radio content has turned out to be a potential step in this direction, the LCRS concept less so. By pooling our results, we arrive at the following design recommendations (DRs) for radio innovation:

DR1: Never lose sight of the loyal listeners who enjoy radio's passive yet carefully curated listening experiences. Rather than blindly copying over features from streaming services in an attempt to win back music streamers, innovation must respect radio's defining traits (e.g., shared lived experience, background function) to keep its traditional listener base satisfied.

DR2: Capitalize on radio's storytelling strengths by further perfecting but also nurturing the craftsmanship of radio making (e.g., via innovative production tools or by facilitating the integration of User-Generated Content in radio production).

DR3: Widen the reach and accessibility of ephemeral radio content by affording greater consumption flexibility (e.g., on-demand listening to radio content).

DR4: Personalization is a good candidate to consider in every radio innovation attempt, both in live contexts (e.g., the tested substitution concept, notifications for on-air content) and in combination with offline consumption (e.g., [57]). However, personalization opportunities must be optional so that traditional listeners can opt

out of using it. Also, users must have insight into how and why personalization choices were made and must have the power to overrule them.

DR5: Let users flexibly choose between a traditional, lean back radio experience and a more demanding (but possibly also more rewarding), lean forward type of radio consumption (e.g., via configurable personalization options, see DR4).

By balancing these recommendations, it should be feasible to make radio more attractive for consumers who think radio in its present form is too old-fashioned (DR4-5), without hereby making radio lose its charm for its loyal user base (DR1-3). Intricate yet optional personalization opportunities (DR4) seem especially important to the future of radio, as they hold the power to bridge the gap between both these user groups.

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