Reception of Terrestrial DAB+ and FM Radio with a Mobile Device: A Subjective Quality Evaluation

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Abstract. Nowadays, terrestrial broadcasting enables to receive content anytime and everywhere. People can obtain information both with a portable or desktop receiver, which include pocket-sized devices as well as high-end Hi-Fi equipment, not to mention car audio systems. Numerous manufacturers include FM-compatible chipsets in a variety of user equipment (UE), including mobile phones. However, digital radio signal processing modules, such as, i.e., Digital Audio Broadcasting plus (DAB+), are not that popular. Currently, only one smartphone available on the market offers such possibilities This paper examines the reception quality of terrestrial digital DAB+ and analog FM radio with the use of a mobile device. The study was carried out on a number of broadcasts simulcasted in both standards, and involved a group of 30 listeners aged between 20–25 years old. Next, results were compared with subjective scores obtained using a high-end desktop radio receiver. The aim of this work is to determine whether small size mobile UE can offer high-quality reception, and whether a smartphone can compete with a traditional indoor receiver. Results of carried out studies may aid and inspire devices manufacturers as well as content and service providers, speeding up the whole digitization process.

Keywords: Coding · Compression · Mobile Devices · Signal Processing · Quality Evaluation

1 Introduction

Terrestrial radio transmission accompanies us every day during numerous activities. Whether we are traveling to work or during vacations, we like to stay informed about, e.g., traffic and weather conditions. We also like to listen to music during every day routines or just to relax ourselves. The market offers numerous radio receivers, compatible with, e.g., analog FM, Digital Radio Broadcasting plus (DAB+), Internet streaming services, not to mention numerous wireless interfaces like Bluetooth, that enable us to connect headsets, etc. [1]. However, most people are interested particularly in portable devices, such as the smartphone [2]. Almost every device running on Android or iOS has a build-in chipset

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responsible for processing analog radio signals. Therefore, it is quite intriguing why manufacturers do not offer compatibility with a variety of digital terrestrial services. Among them, DAB+ is the most widely-spread standard for transmission of digital radio [3, 4]. Yet, only one mobile device is capable of processing and presenting this type of content. This paper is focused on a study, considering the reception of terrestrial FM and DAB+ radio with a smartphone. Its main aim is to determine whether such user equipment (UE) can compete with the quality offered by more pricy high-quality desktop devices. That is why this subjective evaluation was carried out. Previous investigations considering the advancements in the broadcast industry as well as the radio digitization process are well-summarized in [5].

2 Digital Radio Market

In [6], the author focuses on the considerable scale and pace of change in broadcast radio over the first two decades of the twenty-first century, an on-going process showing little sign of abating. Developments in digital broadcasting, the increasing consumption of audio via Internet protocol (IP) and the arrival of the smart speaker are all major factors impacting the future of radio broadcasting. No longer a stand-alone medium, this paper argues that the future of broadcast radio rests on the way in which it addresses the various challenges and opportunities offered by its use of new technologies and multiple platforms. Change is not simply being driven by technological and regulatory developments within the industry. Equally importantly, change is also being driven by external factors and by wider societal pressures. Today, radio faces greater levels of challenge and competition than at any time in its long history.

Public service broadcasting (PSB) is generally characterized by a remit to provide high-quality news, educational content, cultural enrichment and entertainment as free public goods with as broad a public reach as possible, while also filling critical gaps in the media ecosystem. However, in the current digital environment, the ability to reach audiences is increasingly intermediated by online platforms managed by powerful technology companies who do not necessarily share the same objectives or values as PSBs. In [7], interviews were conducted with PSB executives and managers working on digital products and strategy in the U.K. and U.S., to examine the challenges and tensions PSB entities face in the context of growing commercial platform power and the strategies emerging in response, such as investing in new platforms and digital infrastructures rooted in traditional public service values. The study also discusses differences in capacities to respond to platform power between the decentralized U.S. PSB system and centralized U.K. system. Finally, the study discusses some theoretical and practical implications, and suggests ways PSB services might survive and thrive with robust fidelity to democratic needs.

The aim of this work [8] was to perform an analysis of the current state of various digital broadcasting systems around the world and the switchover trends from the analog to digital domain, as recommended by the International Telecommunication Union (ITU). As shown, the main cause is not only the lack of unoccupied frequency resources, but also the society's growing demands for up-to-date information and content.

Another paper [9] focuses on breakdowns experienced in the media field due to technology and digitization. As shown, concepts such as speed, mobility, screen, connectivity and interaction are rapidly finding application in digital media environments. When viewed from this perspective, it is seen that many new media production areas with technology references have emerged. One of these new areas are digital radios. With the traditional analog broadcasting being replaced by digital over time, it has become much more efficient to deliver content in the virtual environment. From now on, broadcasts are no longer a media tool that is listened to, but also a communication environment that can be watched and interacted with. Thanks to the web technology that transforms the radio into a watchable platform, it is seen that the content reaches the listener and the audience through the screens. For this reason, it can be said that the area of influence of radio broadcasting has expanded and radio broadcasting has taken a much more active position in the media sector.

As the lines between production, distribution, and platform technologies blur, and as the digital transformation moves to the cloud, the European Broadcasting Union (EBU) Technical Committee's work becomes more important than ever, as members seek the scale and sophistication that typifies global super aggregator offerings. EBU's focus is on delivering the products and facilitating the exchanges that underpin the strategic elements in these transitions by federating the members' interests [10]. Yet still, work could be done in order to familiarize users with the possibilities digital radio can offer.

3 About the Study

3.1 Multiplex Configuration

The tested DAB+ multiplex consisted of 9 services transmitting audio content, with bitrates ranging from 64 to 128 kbps. Among them, some delivered mostly speech signals, while other broadcasted typically music signals, whereas some provided mixed speech-music signals, depending on the profile of a particular radio station. The relation between type of broadcasted audio content and bitrate of respective radio programs is discussed in [11].

Generally speaking, the HE-AAC v1 variant of the coding algorithm is utilized in case of the lower bitrates, whereas the AAC-LC variant is used when processing audio content at higher bitrates. The description of each evaluated radio program in this particular experiment is described in Table 1.

As observed, some broadcasts are simulcasted in analog FM radio (6 out of 9). Each services was evaluated in a subjective study with two receivers, namely a mobile as well as desktop device.

Table 1. Configuration of the tested DAB+ multiplex.

No	Profile	Codec	Bitrate [kbps]	Simulcasted in FM
1	Talk 1	AAC-LC	112	Yes
2	Arts	AAC-LC	128	Yes
3	Talk 2	AAC-LC	112	Yes
4	Pop Music	AAC-LC	128	Yes
5	Informative EN	AAC-LC	64	No
6	Informative PL	HE-AAC v1	64	Yes
7	Classical Music	AAC-LC	128	No
8	Children	HE-AAC v1	72	No
9	Regional	AAC-LC	112	Yes

3.2 Tested Devices

The tested devices included a mobile UE, namely the LG Stylus 2 [12], which quite surprisingly is still the only smartphone with DAB+ reception compatibility available on the market. Although it was released in Q1 2016, the newer generation of the Stylus line did not offer such features. The principle technical specification of this device is described in Table 2.

Table 2. Principal technical specification of the LG Stylus 2 smartphone.

Feature	Description
CPU	4-core, 1.20 GHz
RAM	2 GB
Supported terrestrial radio standards	FM, DAB+
Audio output	3.5 mm jack
Storage	16 GB (build-in), microSD-card slot (external)
Communication	Bluetooth, Wi-Fi, 2 G, 3 G, 4 G
Operating system	Android 6.0 Marshmallow

Whereas, the principal technical specification of the desktop radio receiver, namely TechniSat DigitRadio 350 IR [13], is described in Table 3.

As shown, the desktop receiver is a hybrid device, enabling to handle both terrestrial FM and DAB+ radio, as well as other various audio sources. After a careful examination, no data were available considering the type of integrated chipset in case of each receiver, responsible for handling terrestrial radio signals. Nevertheless, both were subjected to the same testing procedure.

Table 3. Principal technical specification of the TechniSat DigitRadio 350 IR receiver.

Feature	Description
Supported terrestrial radio standards	FM, DAB+
Audio output	3.5 mm jack,
Storage	USB (external)
Communication	Wi-Fi, Ethernet, USB

3.3 Testing Procedure

Tests were carried out in turns, one participant after another, according to [14]. The group of listeners involved 30 individuals aged between 20–25 years old. At first, they evaluated the DAB+ radio programs, presented in a randomized manner, and then switched to the simulcasted FM radio program. Of course no one was informed about the name nor bitrate (in case of DAB+) of the currently assessed broadcast. Each DAB+ and FM program was presented over a period of approx. 20 s, separated by a 5 s interval necessary to write down the scores.

Listeners started their evaluation with a mobile UE, and then repeated the whole procedure with the desktop receiver. Each one took a 5–10 min break before moving from one device to the other. Neither of them had hearing impairments.

The quality evaluation took place in an indoor environment, with both devices set to fixed locations next to each other. The subjective study was carried out using Beyerdynamic Custom One Pro headphones. Each individual was allowed to set the volume level according to his or her preferences during the training phase. The tests were performed over a period of one week.

4 Results

Results of the subjective quality evaluation study, in a 5-step variant of the Mean Opinion Score (MOS) scale from 1 (bad quality) to 5 (excellent quality), carried out on both mobile and desktop devices, considering a group of 30 individuals, are shown in Figs. 1, 2, 3 and 4. The scores obtained for all 9 DAB+ radio broadcasts are shown in Fig. 1.

It can be summarized that each radio program, except for Informative EN on a desktop device, received an overall score of above 4.0. Additionally, the difference between respective broadcasts was quite small. Figure 2 shows the Subjective Difference Grade (SDG) concerning scores obtained for DAB+ radio on both devices, based on data presented in Fig. 1. Quite surprisingly, listeners tend to favor the mobile UE.

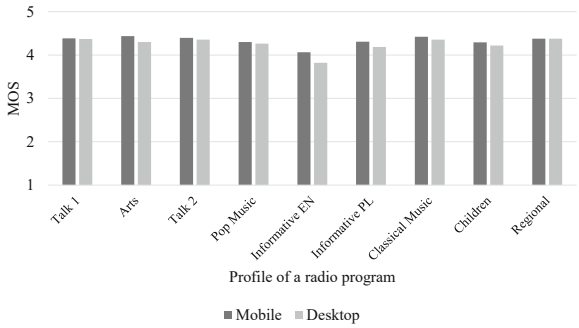

Fig. 1. Subjective quality evaluation of DAB+ radio programs.

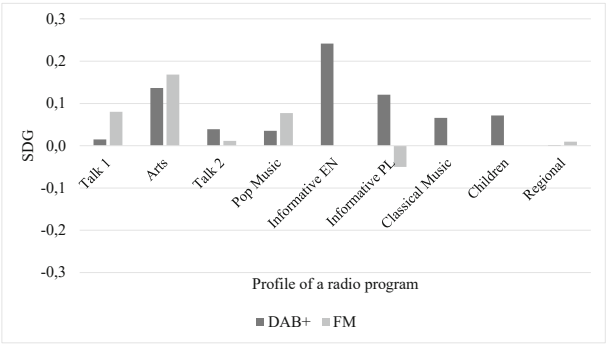

Fig. 2. Subjective difference grade of DAB+ radio programs.

Results considering the reception quality of FM radio, are shown in Fig. 3.

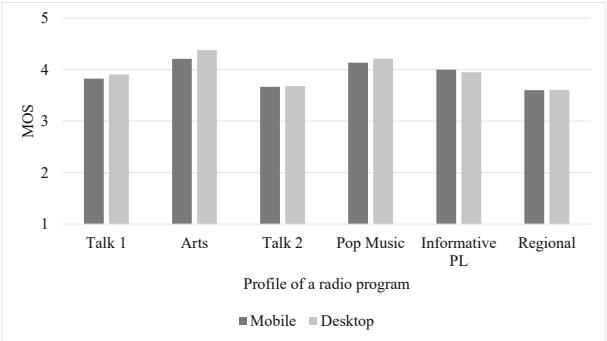

Fig. 3. Subjective quality evaluation of FM radio programs.

In case of analog FM radio, except for the Informative PL program, the desktop device proved to be superior over the smartphone. As shown in Fig. 4, describing the SDG of FM scores, based on data presented in Fig. 3, the MOS grades were simply higher. Additionally, some broadcasts received a score lower than 4.0 (between acceptable and good quality). This experiment also shows a clear advantage of the digital standard over the analog.

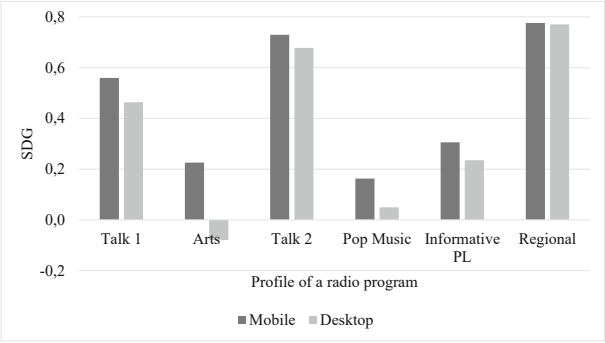

Fig. 4. Subjective difference grade of FM radio programs.

When statistically compiling obtained data using the analysis of variance (ANOVA) method, the confidence intervals were set to 95% ($\alpha = 0.05$). In all cases, the dispersion was less than 10% of the average values.

5 Conclusions

As shown, a portable light-weight device offers comparable reception quality to a heavier desktop one. The modern-day smartphone, with its possibilities of receiving, processing and presenting rich media content, is a handy companion in numerous activities [15–17]. According to obtained results, the digital DAB+ radio standard offers higher quality content compared to analog FM radio. Furthermore, a DAB+ compatible smartphone offers as good as, and sometimes even higher, audio reception quality than traditional household receivers. Therefore, integrating the digital radio standard into a wider range of consumer UE, particularly smartphones, would speed up the digitization process, as well as help the industry in the switchover process.

In the nearest future, it would seem interesting to perform similar studies considering different age groups, concerning both younger and older individuals with varying quality expectations and user preferences. Furthermore, it would seem interesting to evaluate people with different backgrounds, including those with audio-visual impairments, that are keen on technology and frequently listen to radio broadcasts. Another aspect is the design of the user interface itself, regardless whether talking about a physical receiver device or a mobile application.

As we know, digital terrestrial radio offers much more possibilities that the mere transmission of audio signals in the form of speech and music content. Therefore, efforts

could be made in order to determine the potential of possible advertisements that could raise the overall income of broadcasters. This would certainly speed up the digitization process and the switchover from the analog to digital domain. Additional source of inspiration that may encourage future study directions, focused on the digital radio market and related fields in numerous countries around the world, may be found in [18–26].

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