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**Speech and multimedia Transmission Quality (STQ);
Transmission quality and speech intelligibility
for hearing impaired people**

Reference

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Keywords

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

Modal verbs terminology

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Executive summary

The present document provides data and information on studies that have shown that hearing impaired people are suffering of insufficient intelligibility of transmitted speech, due to background noises, transmission impairments, shapes of receivers, tandeming of speech processing and coupling between earphones and hearing aids.

It also shows that wideband bandwidth provides improved quality than achieved with narrowband for hearing impaired people using hearing aids, cochlear implants.

The present document is intended as a first step of a potential work plan which needs to be constructed in order to define scenarios to conduct subjective tests on intelligibility, listening effort and quality for hearing impaired people with different hearing profiles, and to define and validate an objective model to predict speech intelligibility, listening effort and quality for hearing impaired people, both by using hearing aids or not. The next phase should consist, at least, to study:

- how the listening quality for hearing impaired people can be improved, with or without hearing devices (including loudness, spectrum equalization or enhancement, etc.);
- how to determine the impact of the different transmission impairments on intelligibility for different types of hearing profiles, such as the potential impact of coupling between phone receivers and hearing aids (e.g. acoustical, inductive coupling);
- which kind of model(s) can best assess objectively the intelligibility of natural and synthesized speech;

- what kind of model could determine the listening effort needed to follow and understand a conversation.

The impairments from the distant send side may also have impacts on intelligibility of received speech, hence might need performance improvements.

Introduction

Several studies have shown that hearing impaired people suffer from less sufficient intelligibility of transmitted speech, due to background noises, transmission impairments, types of receivers, low quality coupling between earphones and hearing aids. It was also noted that an important parameter to be assessed is the listening effort.

There is also a lack of subjective tests on intelligibility for hearing impaired people and there is no standardized objective model to predict speech intelligibility as perceived by hearing impaired people. Such tests should be done, at least, in wideband, as very few results are available for this bandwidth and it has been shown that wideband speech provides improvements compared to narrowband speech for hearing impaired people.

The present document is a first step to improve and assess the intelligibility of transmitted speech for hearing impaired people.

It is expected that new documents, specifications or standards could be produced for specific applications, e.g. to associate text to speech in order to improve the intelligibility for the users, and to consider the best way to define relevant standards for these combinations.

For further works, at least four topics have been identified. The three first topics could be developed by the ETSI TC STQ and the fourth topic by the ETSI TC HF (Human Factors):

- Receive side for hearing impaired people, with or without hearing aids (including loudness, equalization, etc.), including modeling the listening effort.
- Impact of the different transmission impairments on intelligibility, quality and listening effort.
- Impairments from the send side and consequences on intelligibility - improvements are expected.
- Association of text and speech, and consequences for intelligibility.

Acoustical, inductive, wireless and electrical couplings between phones and hearing aids should be taken into account, as well as the different types of hearing aids (e.g. cochlear implants).

1 Scope

The present document provides a review of existing test methodologies to assess speech intelligibility, quality and listening effort.

It should be noted that most test methods (for quality or intelligibility) have been developed with normal hearing people and that there is a lack of data for hearing impaired people.

Some clauses of the present document provide a review of existing methods or test results that take into account couplings between phones and listener's ears (acoustical coupling), and coupling between phones and hearing aids (inductive, acoustical or via radio links). Different hearing impairments affecting the listening performance are also considered.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] IEC 60118 series: "Hearing aids".

[i.2] Recommendation ITU-T P.10/G.100: "Vocabulary for performance and quality of service".

[i.3] Recommendation ITU-T P.16: "Subjective effects of direct crosstalk; thresholds of audibility and intelligibility".

[i.4] Recommendation ITU-T P.85: "A method for subjective performance assessment of the quality of speech voice output devices".

[i.5] ETSI EN 301 549: "Accessibility requirements suitable for public procurement of ICT products and services in Europe".

[i.6] Recommendation ITU-T P.807: "Subjective test methodology for assessing speech intelligibility".

[i.7] Recommendation ITU-T P.1311: "Method for determining the intelligibility of multiple concurrent talkers".

[i.8] ETSI ES 200 381-1 (V1.2.1) (10-2012): "Telephony for hearing impaired people; Inductive coupling of telephone earphones to hearing aids; Part 1: Fixed-line speech terminals".

[i.9] ETSI ES 200 381-2 (V1.1.1) (10-2012): "Telephony for hearing impaired people; Inductive coupling of telephone earphones to hearing aids; Part 2: Cellular speech terminals".

[i.10] ETSI ETS 300 488 ed.1 (01-1996): "Terminal Equipment (TE); Telephony for hearing impaired people; Characteristics of telephone sets that provide additional receiving amplification for the benefit of the hearing impaired".

[i.11] ETSI TR 102 949: "Speech and multimedia Transmission Quality (STQ); Wideband and Superwideband speech terminals; Perceptually motivated parameters".

[i.12] ANSI/ASA S3.2-2009 (R2014): "Method For Measuring The Intelligibility Of Speech Over Communication Systems".

[i.13] Recommendation ITU-T P.862: "Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs".

[i.14] Recommendation ITU-T P.863: "Perceptual objective listening quality assessment".

[i.15] ETSI ES 202 396-1: "Speech and multimedia Transmission Quality (STQ); Speech quality performance in the presence of background noise; Part 1: Background noise simulation technique and background noise database".

[i.16] ETSI EG 202 396-2: "Speech Processing, Transmission and Quality Aspects (STQ); Speech quality performance in the presence of background noise; Part 2: Background noise transmission - Network simulation - Subjective test database and results".

[i.17] ETSI EG 202 396-3: "Speech and multimedia Transmission Quality (STQ); Speech Quality performance in the presence of background noise; Part 3: Background noise transmission - Objective test methods".

[i.18] Ute Jekosch, Technische Universität Dresden: "Test on overall quality as perceived by high frequency hearing impaired subscribers", ITU-T SG12 - C101 - September 2007.

[i.19] John Beerends, Ronald Van Buuren, Jeroen Van Vugt, Jan Verhave: "Objective Speech Intelligibility Measurement on the basis of natural speech in combination with perceptual modeling", JAES, Vol.57, N 5, May 2009.

[i.20] Hearcom project (hearcom.eu).

[i.21] Directive 93/42/EEC of 14 June 1993 concerning medical devices.

[i.22] Report on 2012 HLAA Convention, NB versus WB Speech Study.

[i.23] ITU-T Contribution SG12 - C93 - November 2013: "Subjective and objective measurement of synthesized speech intelligibility in modern telephone conditions".

[i.24] Sridhar Kalluri, Starkey Hearing Research Center (Berkeley): "High frequency sound for the hearing impaired".

NOTE: Available at https://www.itu.int/dms_pub/itu-t/oth/06/17/T061700000D0011PDFE.pdf.

[i.25] Linda Kozma-Spytek. Technology Access Program. Gallaudet University; Washington, DC: "Voice Telecommunications Accessibility for Individuals with Hearing Loss".

NOTE: Available at STQ(14)47_038_Voice_Telecommunications_Accessibility_for_Individuals_with_.zip.

[i.26] Hearing4all.

NOTE: Available at http://hearing4all.eu/EN/.

[i.27] ISO TR 22411: "Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities".

[i.28] ISO/IEC Guide 71: "Guide for addressing accessibility in standards".

[i.29] ANSI/ASA S3.5-1997 (R2012): "American National Standard Methods for Calculation of the Speech Intelligibility Index".

[i.30] ANSI S3.2-1989 (R1999): "Method For Measuring The Intelligibility Of Speech Over Communication Systems".

[i.31] ETSI TS 103 558: "Speech and multimedia Transmission Quality (STQ); Methods for objective assessment of listening effort".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

articulation index: A measure of the intelligibility of voice signals, expressed as a percentage of speech units that are understood by the listener when heard out of context. The articulation index is based on partially empirical, partially theoretical principles to predict the speech intelligibility under known signal-to-noise conditions. Please see Recommendation ITU-T P.10/G.100 [i.2] ("*Definition generally used in psychoacoustics*"*).*

articulation scale: Opinion scale for measuring the impression of clarity felt by a listener. How distinguishable are the words composing the message? (from Recommendation ITU-T P.85 [i.4]).

hearing aids: medical devices in the context of Directive 93/42/EEC (MDD) [i.21] comprising electro acoustic amplifiers including a microphone and a loudspeaker and having a frequency response and dynamic characteristics specific to each person's individual hearing loss

real-time text: form of a text conversation in point to point situations or in multipoint conferencing where the text being entered is sent in such a way that the communication is perceived by the user as being continuous (from ETSI EN 301 549 [i.5])

speech intelligibility: measure of how comprehensible speech is in given conditions

NOTE: Intelligibility is affected by the quality of the speech signal, the type and level of background noise, reverberation, and, for speech over communication devices, the properties of the communication system.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CVC Consonant Vowel Consonant
HF Human Factors
HLAA Hearing Loss Association of America
ICT Information and Communication Technologies
NB Narrowband
PESQ Perceptual Evaluation of Speech Quality

NOTE: Refers to Recommendation ITU-T P.862 [i.13].

POLQA Perceptual Objective Listening Quality Assessment

NOTE: Refers to Recommendation ITU-T P.863 [i.14].

RLR Receiving Loudness Rating
RTT Real Time Text
SII Speech Intelligibility Index
STI Speech Transmission Index
TC Technical Comittee
WB Wideband

4 Coupling between hearing aids and phones

4.1 ETSI Standards on coupling of phones with Hearing aids

At least the following standards define the performance that should be fulfilled when coupling phones with hearing aids:

- Inductive coupling: both ETSI ES 200 381-1 [i.8] and ETSI ES 200 381-2 [i.9] define the requirements and test measurements for the phones intended to be coupled via inductive transmission with hearing aids. ETSI EN 301 549 [i.5] refers also to these two ESs.
- Acoustical coupling ETSI ETS 300 488 [i.10]: This ETS specifies the electro-acoustic performance characteristics of telephony terminals which are intended for direct application to the ear and which provide, at the earphone, additional amplification in the receiving direction compared with the Receiving Loudness Rating (RLR) specified in the relevant terminal standard.
- ETSI TC STQ is currently working on a work Item: "Telephony for hearing impaired people; Characteristics of wireless and VoIP speech terminals that provide additional receiving amplification for the benefit of the hearing impaired".
- The hearing aids performance are standardized in a series of standards referenced as IEC 60118 [i.1].

It should be taken into account that this ETS does not apply to wireless or VoIP speech terminals, does not take into account handsfree speech terminals and applies only to narrowband speech.

In addition to requirements on "magnetic coupling" (defined as "inductive coupling" in the ETSI ES 200 381-1 [i.8] and ETSI ES 200 381-2 [i.9]), ETSI EN 301 549 [i.5] defines requirements for speech volume gain as follows:

- *"Speech volume range: Where ICT hardware has speech output, it shall provide a means to adjust the speech output volume level over a range of at least 18 dB".*
- *"Incremental volume control: Where ICT hardware has speech output and its volume control is incremental, it shall provide at least one intermediate step of 12 dB gain above the lowest volume setting".*

4.2 Impact of wideband on speech understanding

Report on 2012 HLAA Convention NB versus WB Speech Study [i.22].

"Summary: Testing of narrowband versus wideband telephone speech was completed at the 2012 HLAA convention with a group of 22 cochlear implantees. Results showed access to wideband telephone audio improved speech understanding (in quiet) over speech understanding using typical narrowband telephone audio. In addition, an advantage was found for wideband audio among participants in terms of lowering the ***mental effort*** *expended during completion of the speech understanding task compared to that expended during task completion for narrow band audio testing."*

5 Subjective tests

5.1 Introduction

Recommendation ITU-T P.16 (11/1988) - Subjective effects of direct crosstalk; thresholds of audibility and intelligibility) [i.3] and Recommendation ITU-T P.85 (06/1994) -A method for subjective performance assessment of the quality of speech voice output devices) [i.4] may be considered as initial materials, but are no more sufficient for the modern devices and networks.

Recently, ITU-T Study Group 12 has developed the new Recommendation ITU-T P.807 [i.6]. However, the Recommendation has been validated only with normal hearing people.