STATUS OF SPEECH INTELLIGIBILITY STUDIES AND MODELS FOR HEARING IMPAIRED PEOPLE.

PLANS FOR STANDARDS

Jean-Yves Monfort. JYMCIS
1. Hearing Losses and impacts on speech intelligibility
2. Acoustical coupling between Hearing Aids and Phones
3. Wideband versus Narrowband. The benefits for quality and intelligibility
4. Listening quality tests in Narrowband. Normal and impaired hearing
5. Speech intelligibility models
6. Standardization plans
1. HEARING LOSS AND IMPACTS ON SPEECH INTelligibility

- ISO/TR2241 presents a summary of data:
  From ISO 7029: audibility thresholds until 8kHz, in quiet environment
  for older people (with a reference based on 18 years old people)
  Males and Females for 50% percentiles (upper curves) and 10% percentiles (lower curves).
  → Need for level adjustment for people with hearing loss.

The losses in medium and high frequencies impact speech intelligibility

When high hearing losses, outer hair cells are destroyed, which reduce the selectivity of hearing and the consequently the clarity of sounds.

→ In noisy environment, the minimum difference between signal and background noise (to hear the signal within the noise) increases for older people, in medium and high frequencies (from JIS S 0014:2003)
1. HEARING LOSS AND IMPACTS ON SPEECH INTELLIGIBILITY

- Data from ISO/TR2241: the 10th percentile hearing threshold curve of persons aged 20 (curve B) and 60 (curve A), respectively defined in ISO 226 and ISO 7029.

Test conditions:
- Pure tone
- Frontal incidence
- Free-field
- Quiet environment.
1. HEARINGLOSS AND IMPACTS ON SPEECH INTELLIGIBILITY

Word recognition rate (curves A) increases faster for young (C, doted line) than for old (D, continuous line) people, when Signal/Noise Ratio increases. Listening difficulty (curves B) is increased for older people.
2. ACOUSTIC COUPLING BETWEEN HEARING AIDS AND PHONES

- Several studies (including Hearcom deliverables) pointed out the difficulties for users to ensure a fine acoustical coupling between mobile phones and hearing aids.

- An ongoing study, conducted in USA (ATIS HAC Incubator, Working Group 11), of audio input and volume control when coupling 6 different wireless terminals (with some differences in frequency curve above 1kHz) and 10 Hearing aids (two types: In The Ear and Behind The Ear), adjusted for people with severe hearing losses. Use of real speech signals. Tests on HATS (Head and Torso Simulator), with the use of a probe microphone inside the artificial ear.

- ANSI/TIA-PN-4953 Amplified Telephone Acoustic Hearing Aid Compatibility
  The study is based on the observation that the coupling between the phone receiver and the hearing aid introduce rather high leakages that between the phone receiver and the ear of a normal hearing user. This suggests to test the frequency response and level of the receiver output should be tested with a lower pressure.
For perceived quality

Source: Sridhar Kalluri, Starkey Hearing Research Center (Berkeley, USA)

The study are based on Listening tests using pair comparisons and speech and musics stimuli.

Results: Where normal hearing people prefer bandwidths higher than 10kHz, for most impaired listeners extending bandwidth from 4 kHz (Narrowband for telephony) to 6 kHz (available with wideband -100Hz-7kHz) gave benefit for sound quality.

Potential benefits: Language development in children, spatial hearing, listening effort, sound-source segregation, sound quality

The development of wideband transmission (mobile, DECT, VoIP,...) gives also benefits for hearing impaired people.
3. WIDEBAND VERSUS NARROWBAND. THE BENEFITS

- **For intelligibility** - TIA study (thanks to Linda Kozma-Spytek)

Test of narrowband versus wideband speech with a group of 22 cochlear implantees (during 2012 HLAA Convention)

**Results** : Wideband audio improves speech understanding in quiet environment, compared with speech understanding using typical narrowband telephone audio (Paired t-Test using recognition of 102 words).

Other advantage for wideband: lowering the mental effort
4. LISTENING QUALITY (NARROWBAND) NORMAL AND IMPAIRED HEARING

- Tests have been done within European Project Hearcom.eu
- Listening only tests 2 languages (Dutch and German), phases of at least 15 seconds, 2 male and 2 female talkers. Several narrowband coders, different values for packet loss and bit error rate.
  - They were the first tests with hearing impaired participants evaluating the overall quality at the receiver side and not the measured speech intelligibility. One should be aware, that overall quality and listening effort match very well for hearing impaired subscribers, but do not match with the measured speech intelligibility.

- Tests done with normal hearing and hearing impaired participants. The choice of the hearing impairment was done with respect to the major form of hearing impairment (high frequency loss, ski slope type), which is found especially in elderly people. Participants could adjust the listening volume level of the phone (see results on next slides).
4. LISTENING QUALITY (NARROWBAND) NORMAL AND IMPAIRED HEARING

Tests have been done within European Project Hearcom.eu

- The second experiment covers combined technical disturbances (environmental noises, use of noise cancellers,...). Some additional effects (equalization, time stretching,...) were also tested.
  - As observed by previous studies, there is an apparent higher tolerance of moderate hearing impaired participants towards quality degradations, compared to normal listeners.
  - Noise cancellation also benefits to hearing impaired people, but the best benefit is for normal hearing people (note that these equipments are currently tested by normal hearing people and not hearing impaired people).
  - Time stretching does not help to improve speech quality (possibly due to the lack of naturalness).
4. LISTENING QUALITY. NARROWBAND NORMAL AND IMPAIRED HEARING

Results of Test 1-Hearcom:
Volume Control settings/hearing

Some results of test 2- Hearcom

Quality/level

Quality/cascading

Quality/time stretching

Data for ITU-T Contribution
SG12-C101-2007-Ute Jekosh
A FIRST SET OF SUGGESTIONS

- Need for subjective tests done by hearing impaired people (with and without aids) in addition with tests done by normal hearing people.

- Tests and studies to be developed for wideband speech (in combination or not with narrowband speech)

- Listening quality testing is not enough. Subjective intelligibility tests are needed.
5. SPEECH INTELLIGIBILITY MODELS. ROOM ACOUSTICS

Historically the first standardized model for speech intelligibility (ISO 9921) has been developed for room acoustics: STI (Speech Transmission Index), an index between 0 (unintelligible) and 1.0 (perfectly intelligible), and its relation with speech intelligibility is well established for normal hearing persons. Note that ISO TR22411, Table 16 provides an “STI for older listeners”, estimated from diagrams of reverberation times and S/N ratios.

The STI-approach (IEC 60268-13 -2003-), is closely related to the SII (Speech Intelligibility Index, ANSI S3.5, 1997, revised in 2012), which is a calculation scheme concerned primarily with the effect of interfering noise on speech intelligibility. SII is calculated from acoustical measurements of speech and noise.

- Applications: To design acceptable acoustical conditions in classrooms, meeting rooms, theatres, public-address systems covering large areas, or in public transport.
- Restrictions: the criteria do not take into account the special needs of more vulnerable groups, like elderly, hearing impaired, children in classrooms, or non-native listeners.
5. SPEECH INTELLIGIBILITY MODELS - TELECOMMUNICATIONS

- In telecommunications world, the models are
  - mainly based on quality assessment (e.g., ITU-T Recommendations P.862 -PESQ- and P.863 - POLQA)
  - Validated with subjective test data obtained with normal hearing listeners.

- The parameters impacting the quality and the intelligibility of telecommunications transmissions are significantly different from parameters affecting intelligibility in room acoustics.
5. SPEECH INTELLIGIBILITY MODELS - TELECOMMUNICATIONS

Some recent studies

- **Speech quality measurement for the hearing impaired on the basis of PESQ.** John Beerends, Jan Krebber, Rainer Huber, Koen Eneman, Heleen Luts. Audio Engineering Society Convention Paper, 2008 May, 17-20, Amsterdam

  Linked with Hearcom project. The paper investigates the extent to which PESQ and possible simple extensions can be used to measure the quality of speech signals as perceived by hearing impaired subjects.”

- **Objective Speech Intelligibility Measurement on the basis of natural speech in combination with perceptual modeling.** John Beerends, Ronald Van Buuren, Jeroen Van Vugt, Jan Verhave. JAES, Vol.57, N°5, 2009 May

  The relation between subjective and objective speech intelligibility measurements is researched. For a large series of speech degradations, noise, linear and nonlinear distortions (speech codecs), intelligibility tests were carried out using short CVC words

- **Subjective and objective measurement of synthetized speech intelligibility in modern telephone conditions.** The study based on quality assessment models is presented by Peter Pocta at the present workshop.
6. STANDARDIZATION PLANS ON SPEECH INTELLIGIBILITY IN ETSI

- ETSI STQ has created a new DTS 103 225 “Transmission quality and speech intelligibility for hearing impaired people “ with the following scope:
  - Classification of hearing profiles to be considered in the TS for hearing impaired people with or without hearing devices
  - List of the most significant impairments from terminals, networks and coupling between hearing devices and other terminal devices that may affect the speech intelligibility for hearing impaired people
  - Definition of scenarios and potential test plans for subjective tests to be conducted
  - Definition of a model to assess objectively the intelligibility of natural and synthetized speech

- Other topics for consideration:
  - ETSI STQ has worked on loudness assessment (see DTR 102949). Similar studies should be conducted also for hearing impaired people.
  - Potential action involving ETSI HF: Improvements of intelligibility for hearing impaired people when combining text and speech transmissions

- Collaborations are planned with TIA
Questions?

Thanks

Jeanyves.monfort.6@orange.fr
Currently expert in standardization projects (Quality modelling, ICT accessibility, User QoS,...), mainly in ETSI and « President of Centre de Découverte du Son ».

3 terms as ETSI STQ Chairman
2 terms as ITU-T SG12
Currently retired from Orange Labs, where he was, before leaving Deputy Head of the Media Quality Laboratory and Deputy Director of Standardization.