



Case Study - The Impact of Bluetooth on Speech Quality Performance in Noise Conditions

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Abstract

This case study outlines results from speech quality tests designed to evaluate the affects of using a Bluetooth accessory on speech quality. Specifically, the speech quality experienced by the “landline-listener” in communication with a wireless caller using a Bluetooth device is compared to the speech quality experienced by the landline listener in communication with a wireless caller that is speaking directly into a handset. The report also compares speech quality in noise conditions and presents methods for evaluating speech quality under such noise conditions.

Introduction

Speech quality is of primary concern to providers of voice-based wireless telephony services. The speech quality provided by handsets and their associated accessories affects overall satisfaction with voice services and also impacts the perception of the network’s quality. The ever increasing use of Bluetooth headsets may be affecting the overall speech quality experienced by consumers.

This report addresses the speech quality experienced by the “landline-listener”, i.e., the individual receiving speech from a wireless caller using a Bluetooth headset in a noisy environment.

Speech quality is evaluated using the ITU-T P.835 recommendation whereby a live listening panel scores recorded speech samples.

The speech recording environment is consistent with ETSI Guide 202 396-1 and uses the ETSI noise database for noise input.

Test and Measurement Methods

Speech Quality Measurement

Speech quality is evaluated using ITU-T P.835, a methodology for evaluating the subjective quality of speech in noise and is also appropriate for the evaluation of noise suppression algorithms. The methodology uses separate rating scales to independently estimate the subjective quality of the speech signal alone, the background noise alone, and overall quality.¹ Speech samples incorporate 2 male and 2 female voices.

Each listener is instructed to provide ratings for the *speech signal* as follows:

<i>Score</i>	<i>Quality of speech signal</i>
5	Not distorted
4	Slightly distorted
3	Somewhat distorted
2	Fairly distorted
1	Very distorted

¹ ITU-T P.835 Recommendation 11/2003

Each listener is instructed to provide ratings for the *background* as follows:

<i>Score</i>	<i>Background</i>
5	Not noticeable
4	Slightly noticeable
3	Noticeable but not intrusive
2	Somewhat intrusive
1	Very Intrusive

Each listener is instructed to provide ratings for the *overall speech sample* as follows:

<i>Score</i>	<i>Overall Speech Sample</i>
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

Speech Transmission and Noise Simulation

Speech transmission into the handset or accessory device occurs via a mouth simulator as part of a Head and Torso Simulator system (HATS) consistent with ITU-T P.51 and P.57. The digital speech files resident on a computer are converted to analog signals and played through an audio amplifier to the mouth simulator. Speech levels provided by the mouth are in the range of 75 to 80 decibels. When the handset is being tested, the handset is mounted on the HATS using a standard handset positioner. While the handset using Bluetooth is tested, the Bluetooth device is mounted on the ear pinna and the handset is positioned nearby.

The mouth simulator and the subject handset/accessory are placed at the center of a sound room that provides sufficient acoustic isolation to ensure that external sounds are not present in the recorded audio samples. The sound room also incorporates the noise simulation loud-speakers as part of the noise simulation system.

The noise simulation environment is in accordance with the ETSI Guide 202 396-1. A four-loudspeaker + subwoofer arrangement for playback of binaurally recorded noise signals is used. The background noise recordings utilized are those provided in the ETSI database. The following ETSI sound recordings are utilized.

Car noise (stationary) - Fullsize_car_130kmh.wav
Babble (non-stationary) – Schoolyard.wav
Street (non stationary) - Traffic_crossroads2.wav

The noise levels measured at the mouth position were in the range of:

Car = 62dB (stationary)
Street = 63 to 69dB
Babble = 55 to 60dB

Radio Environment

The radio environment and associated air-interface is provided through a base-station simulator (BTS Simulator). In this case a GSM BTS simulator is used whereby the AMR full-rate 12.2 codec is exercised. All effort is made to provide an error-free radio quality environment with excellent receive signal strength and receive signal quality as reported by the handset under test.

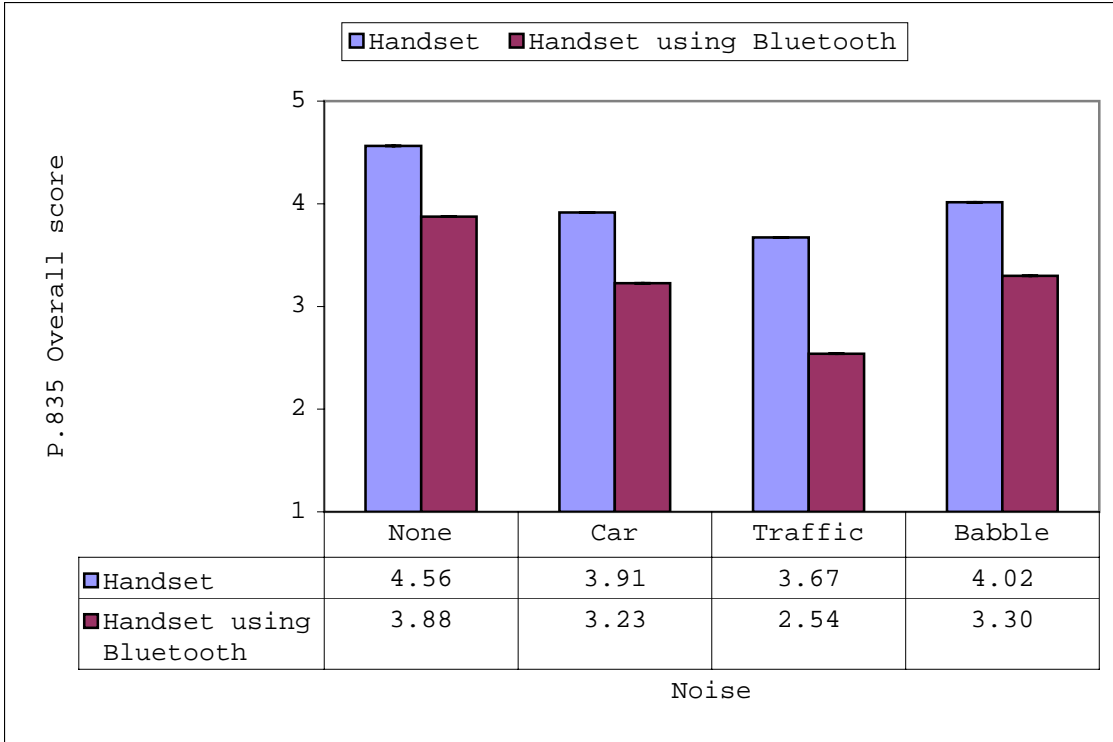
Speech Recording

The speech output connection provided by the BTS simulator provides an analog signal that is then converted to a digital signal and stored as a file on a computer. The speech recordings contain the processed/degraded speech and background noise. The speech files are then prepared for presentation to listeners as per the ITU-T P.835 recommendation.

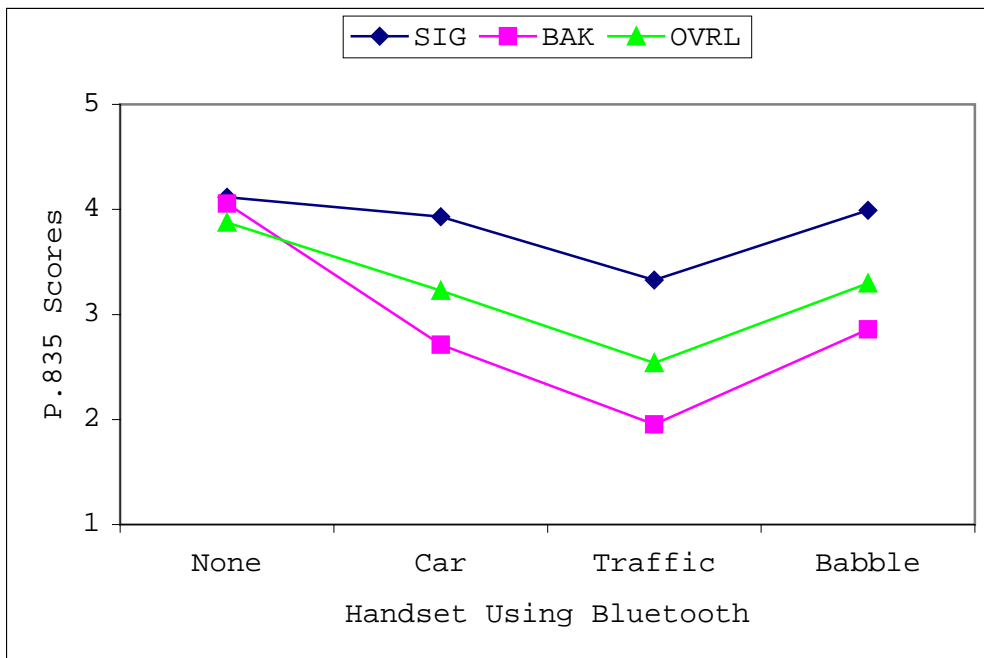
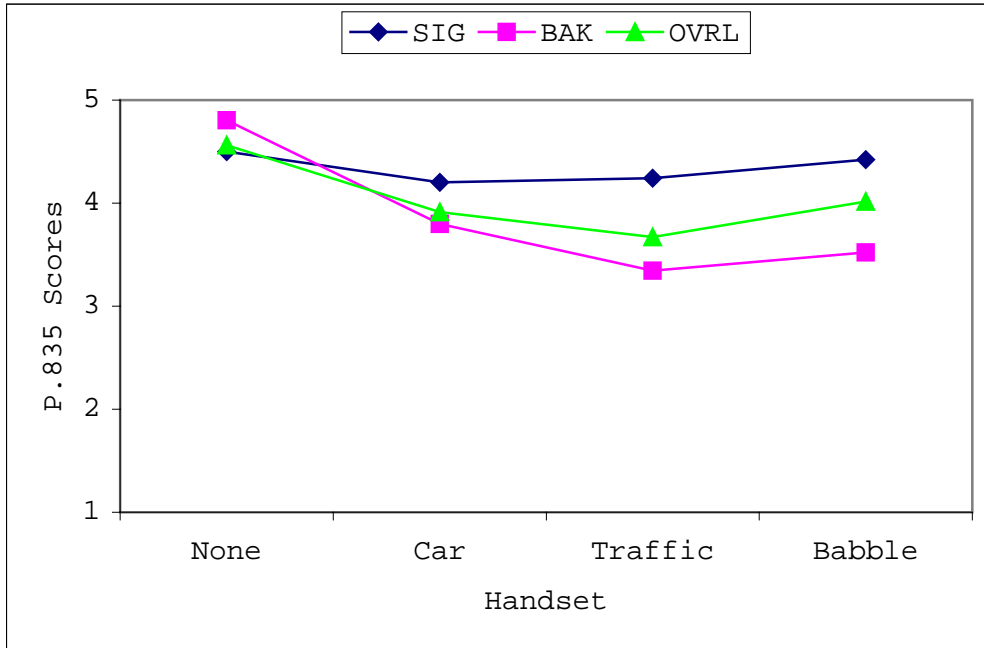
Performance Results

Comparison of P.835 overall speech quality between the (a) handset and (b) handset using Bluetooth.

In all cases, including the no-noise condition, the handset provided a better overall speech quality than the handset using Bluetooth. In the case of traffic noise, the handset was rated 1.13 points better than the handset using Bluetooth.



Comparison of Signal and Background P.835 scores across noise environments
The handset using Bluetooth was found to have a more intrusive level of background noise than the handset alone.



Conclusion

The speech quality experienced by the “landline-listener” in communication with a wireless caller using a Bluetooth device can be significantly degraded compared to the speech quality experienced in communication with a wireless caller that is speaking directly into a handset.

Using the speech quality measurement techniques outlined in this case study, a wireless telephony service provider may assess the speech quality of handsets and handset accessories prior to market release in an effort to ensure the highest levels of speech quality.