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Digital Wireless Phones and Hearing Aids: Interference Issues

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Framework of the Study

Goals:

1. To better understand real-world experience of digital wireless phones for users with hearing aids.
2. To better understand ability of ANSI C63.19 to predict results.

Methods:

- 45 Participants
  - Volunteers from SHHH Convention, June 2002
- Listened to speech over 9 digital handsets:
  - Live networks with good signal [GSM, TDMA, & CDMA].
  - All phones with dynamic loudspeakers at max volume.
  - All backlights off.
- Rated each call on 4 aspects:
  1. Understandability [1=Understood nothing,...,5=Understood everything]
  2. Interference Noise [1=Very annoying,….,5=Imperceptible]
  3. Listening Effort [1=Maximal effort, …, 5=No effort needed]
  4. Overall Quality [1=Bad, 2=Poor, 3=Fair, 4=Good, 5=Excellent]

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Brief ANSI C63.19 Review

RF Measurement: Electric & Magnetic RF Fields around the earpiece are measured. The strongest of all RF measurements is used as worst case and results in a **U-Level** rating. [U1="poor", to U4="excellent"]

Baseband Measurement: Low frequency magnetic fields measured at center of earpiece speaker. The ratio of fields:

$$\frac{\text{Desired + Undesired}}{\text{Undesired}}$$

is used to assign a **UT-Level** indicating telecoil coupling quality. [UT1="poor", to UT4="excellent"]

Hearing Aid Measurements: Immunity levels measured and U-Levels assigned

System Classification:

U-Level Sum ≥ 6 → Excellent Performance

U-Level Sum ≤ 3 → Not Usable Together

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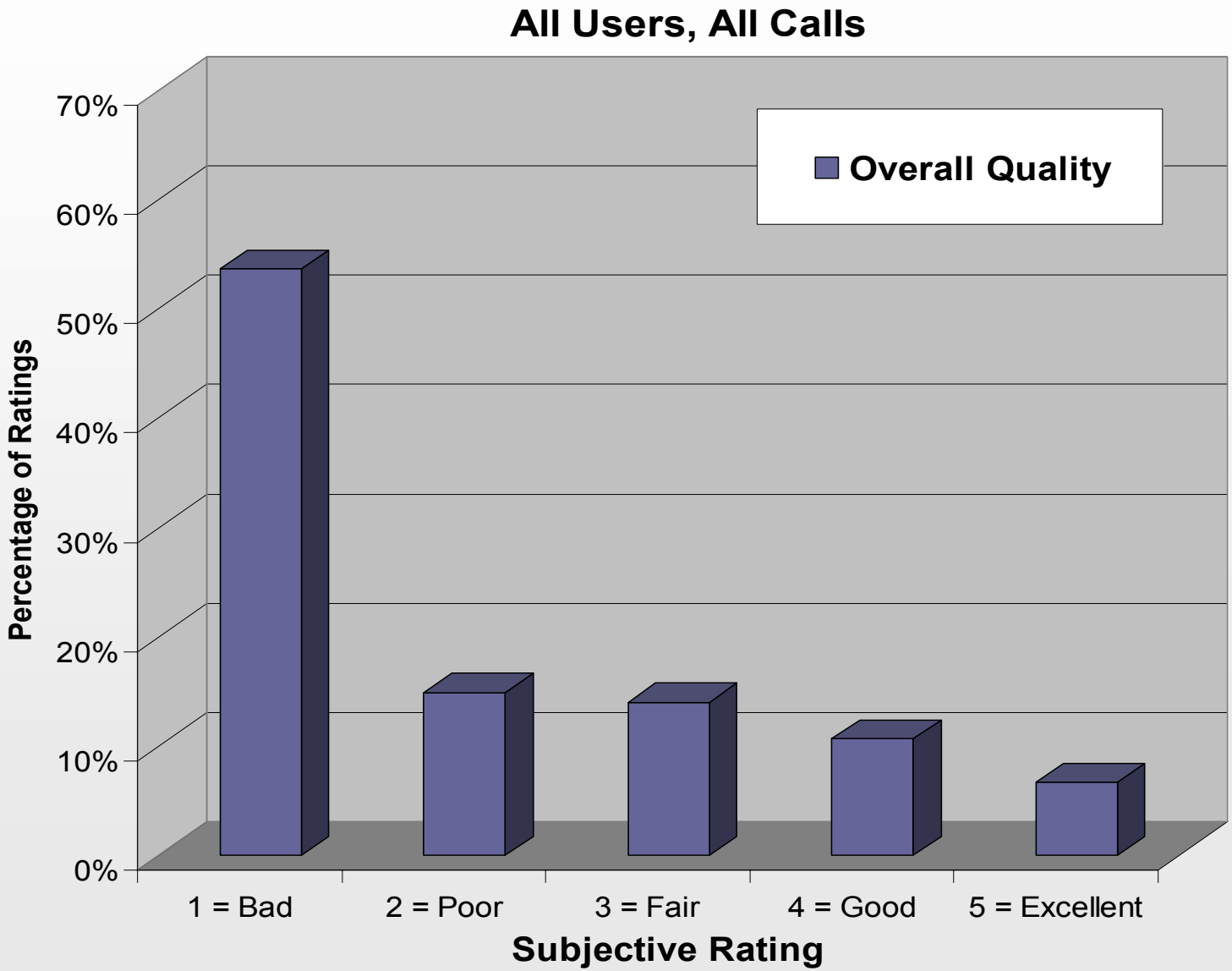
Subjective Rating Results: 1



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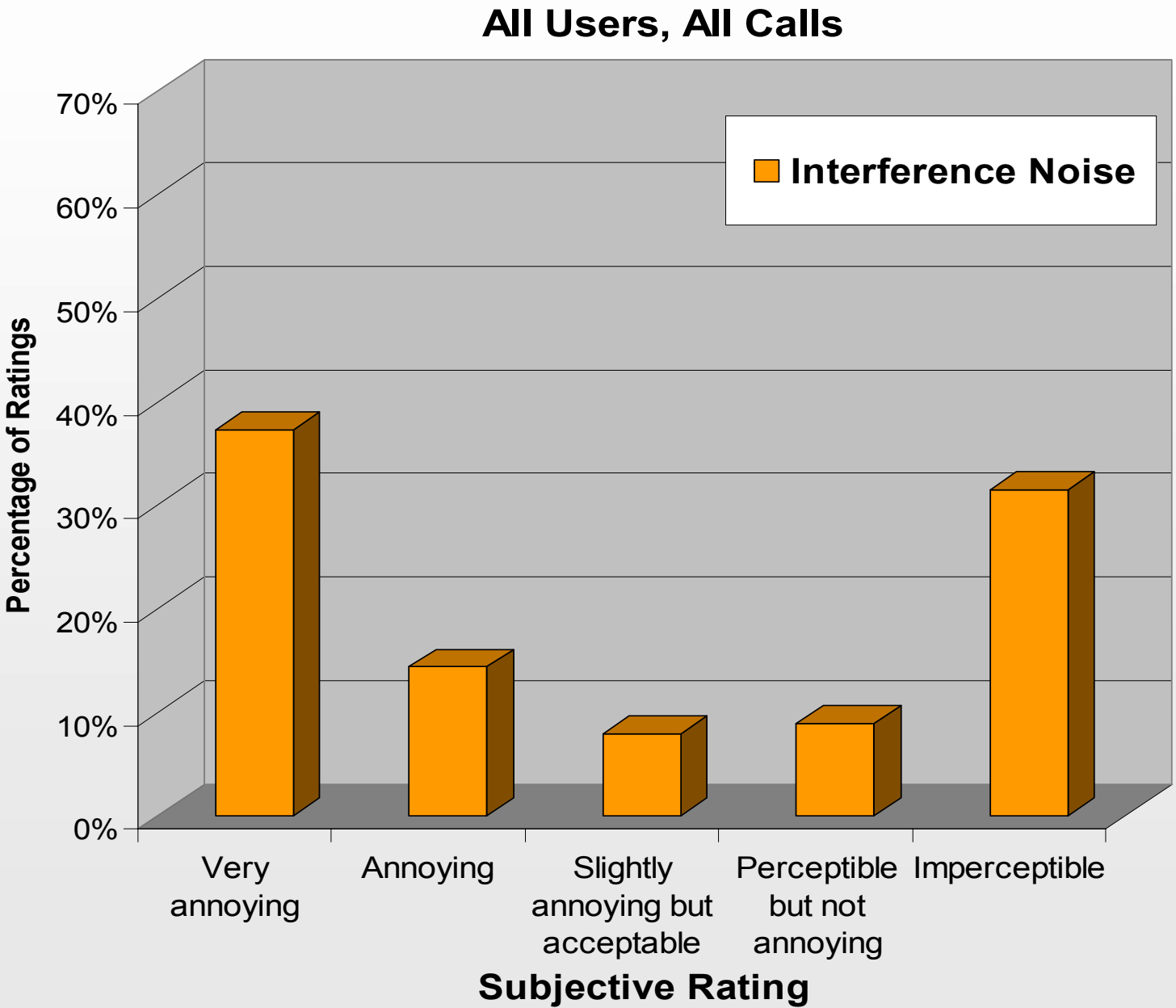
Subjective Rating Results: 2



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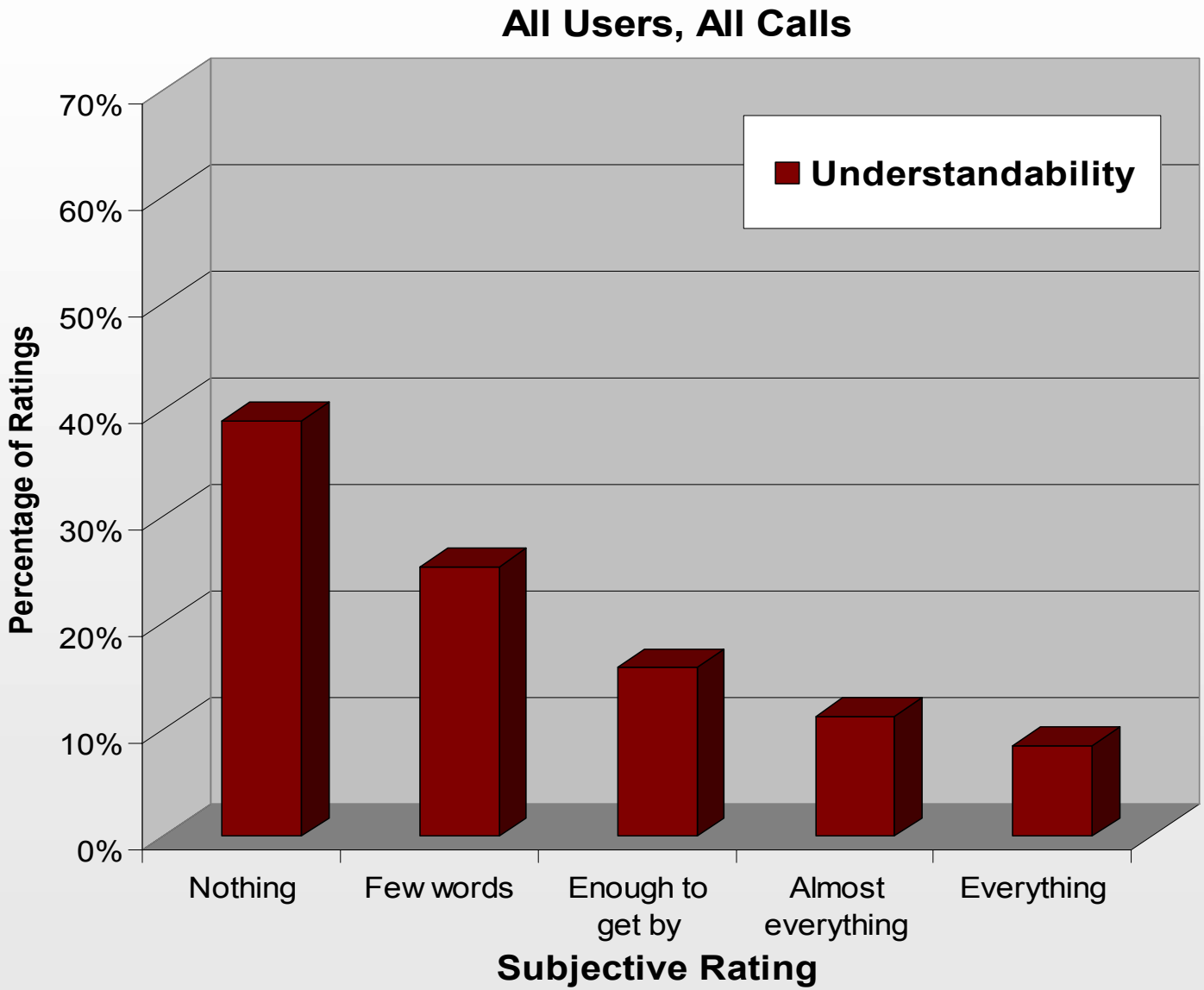
Subjective Rating Results: 3



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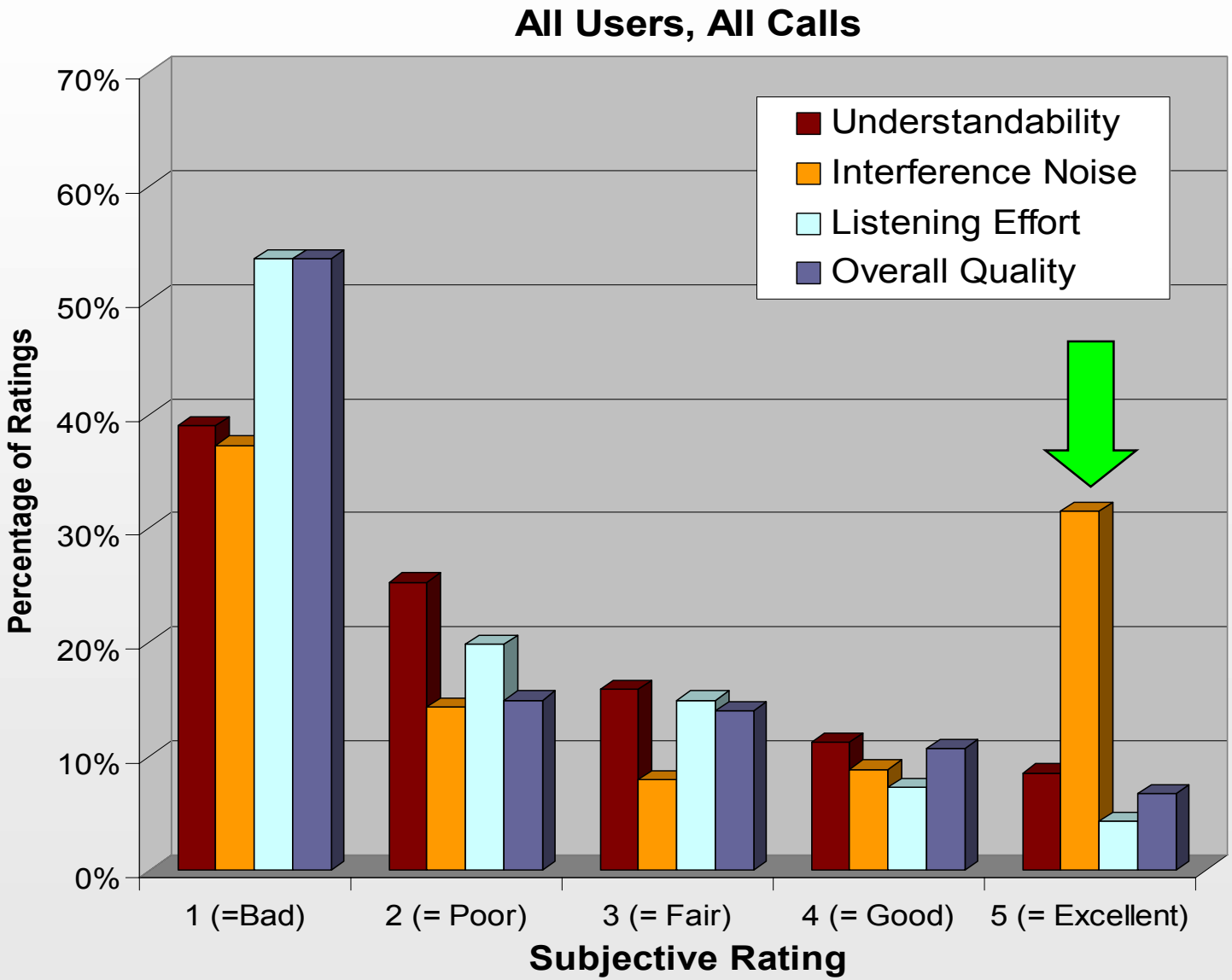
Subjective Rating Results: 4



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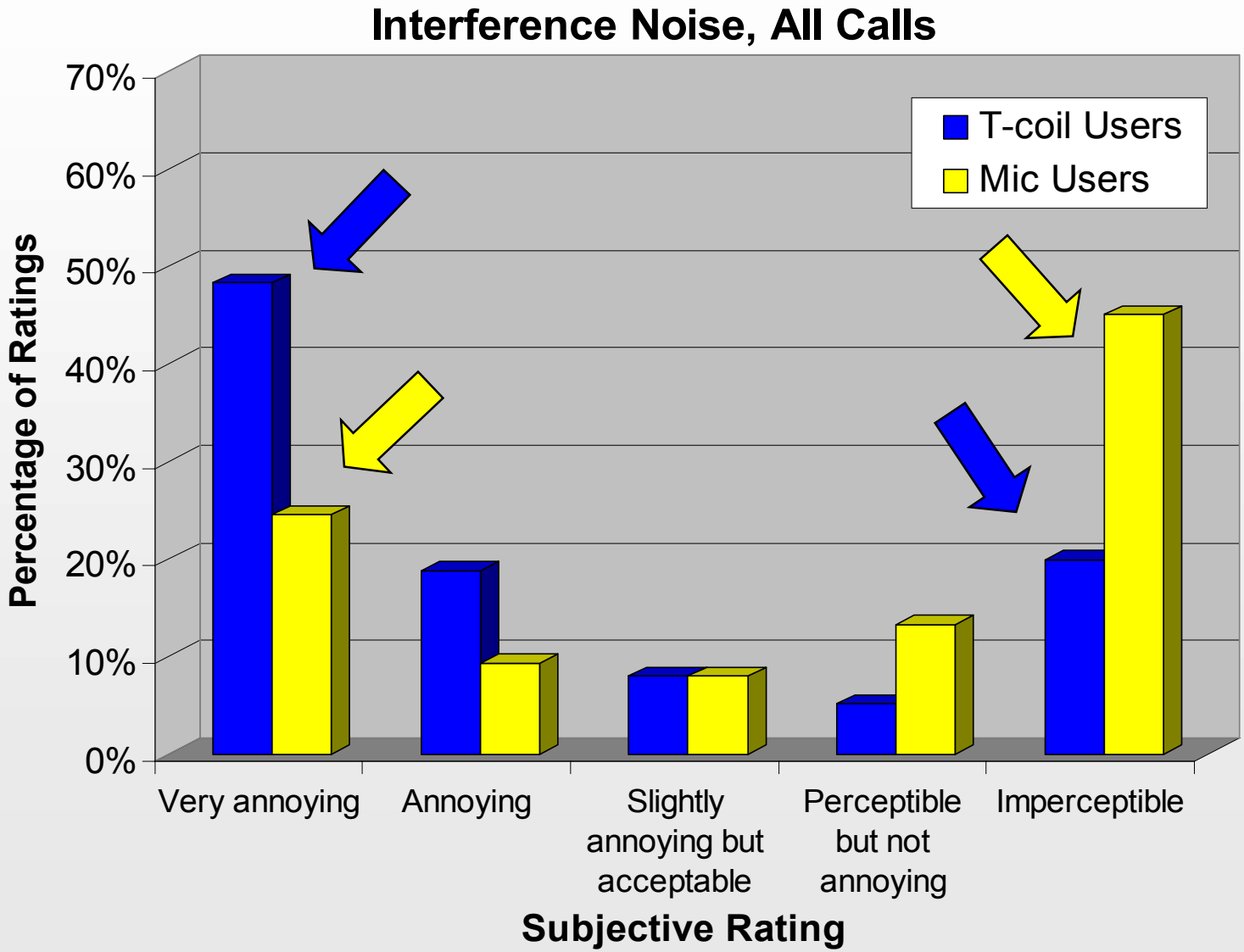
Hearing Aid Mode & Interference



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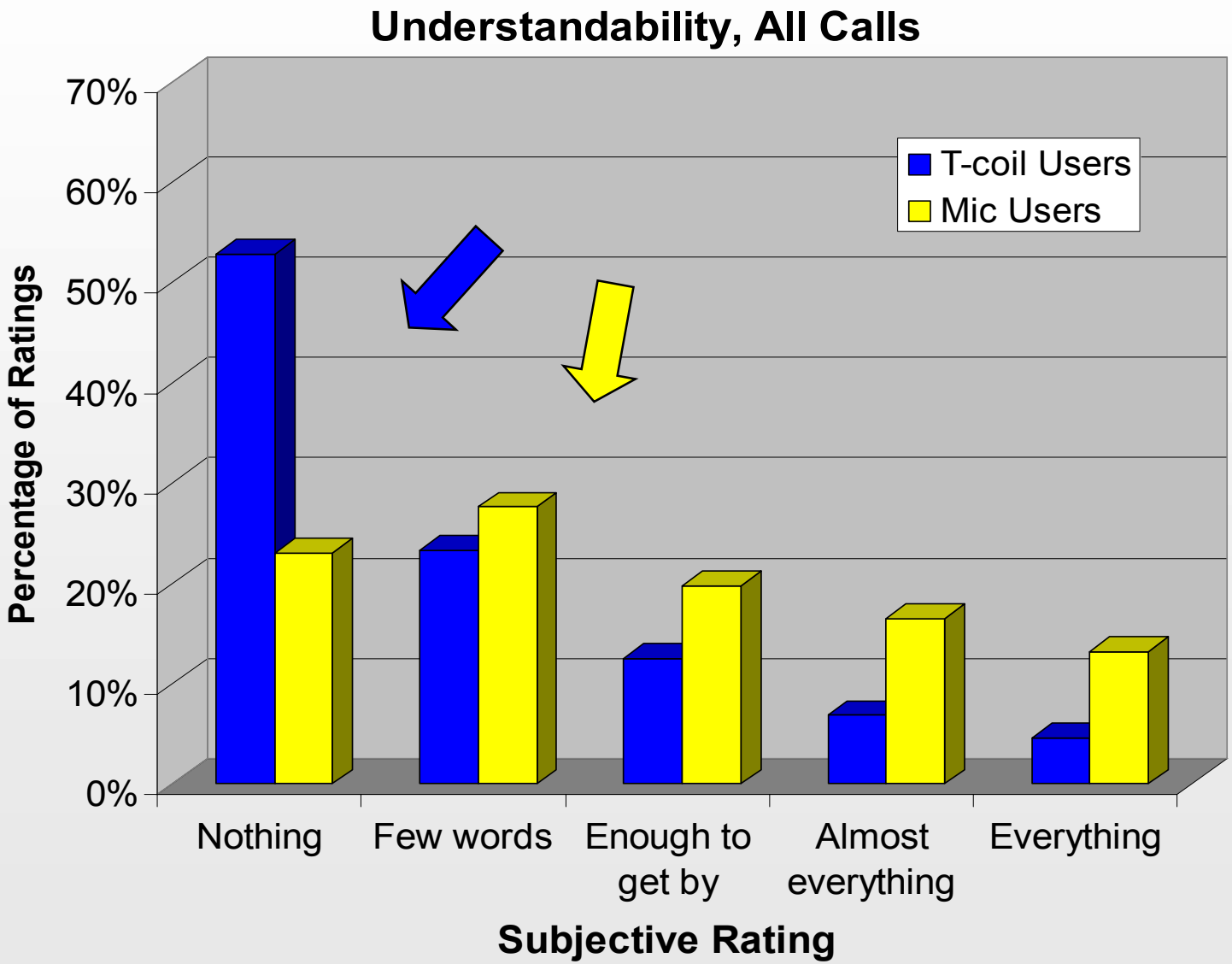
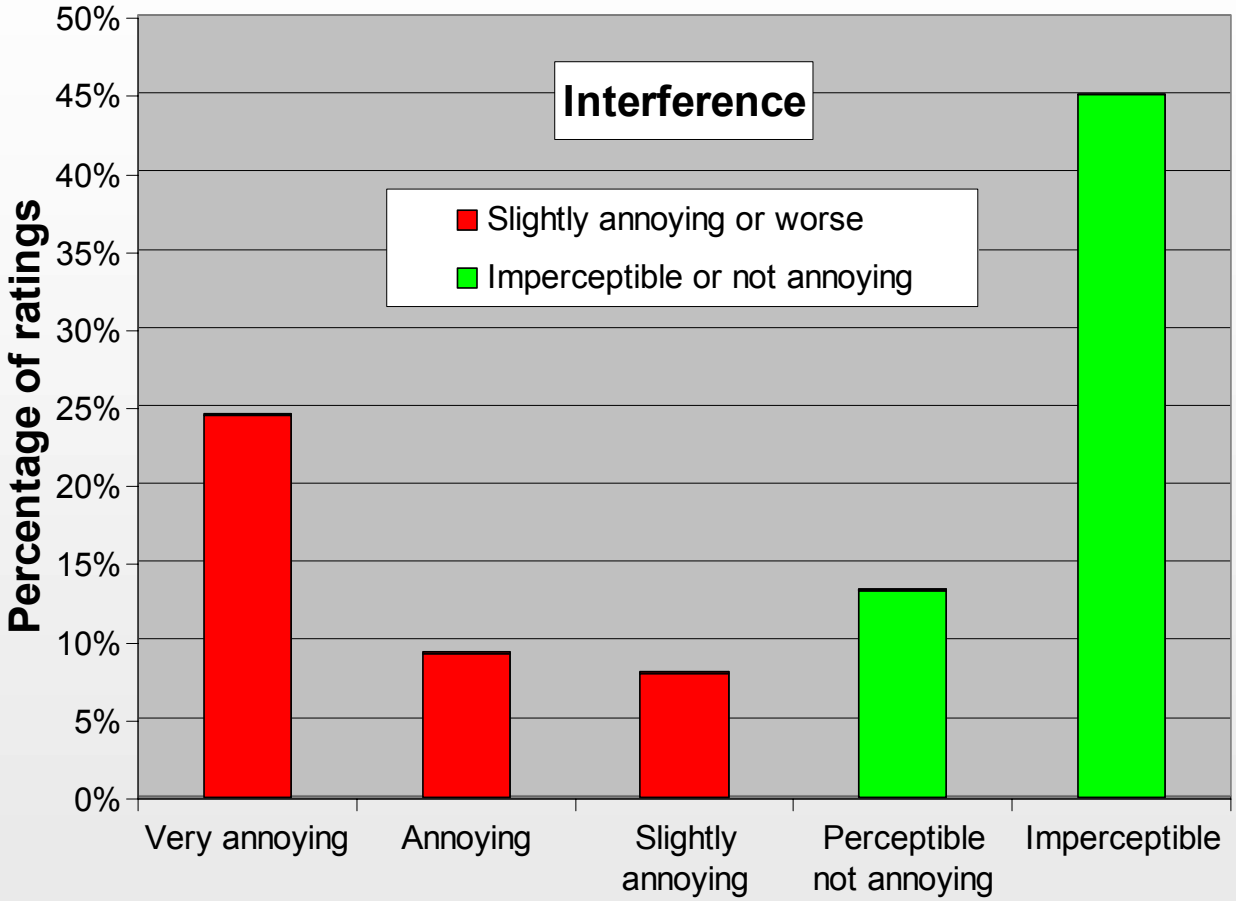
Hearing Aid Mode & Understandability



Some hearing aids performed well with respect to interference



Focus on those mic-mode users who rated **Interference** as either *Imperceptible* or *Perceptible, but not annoying*.

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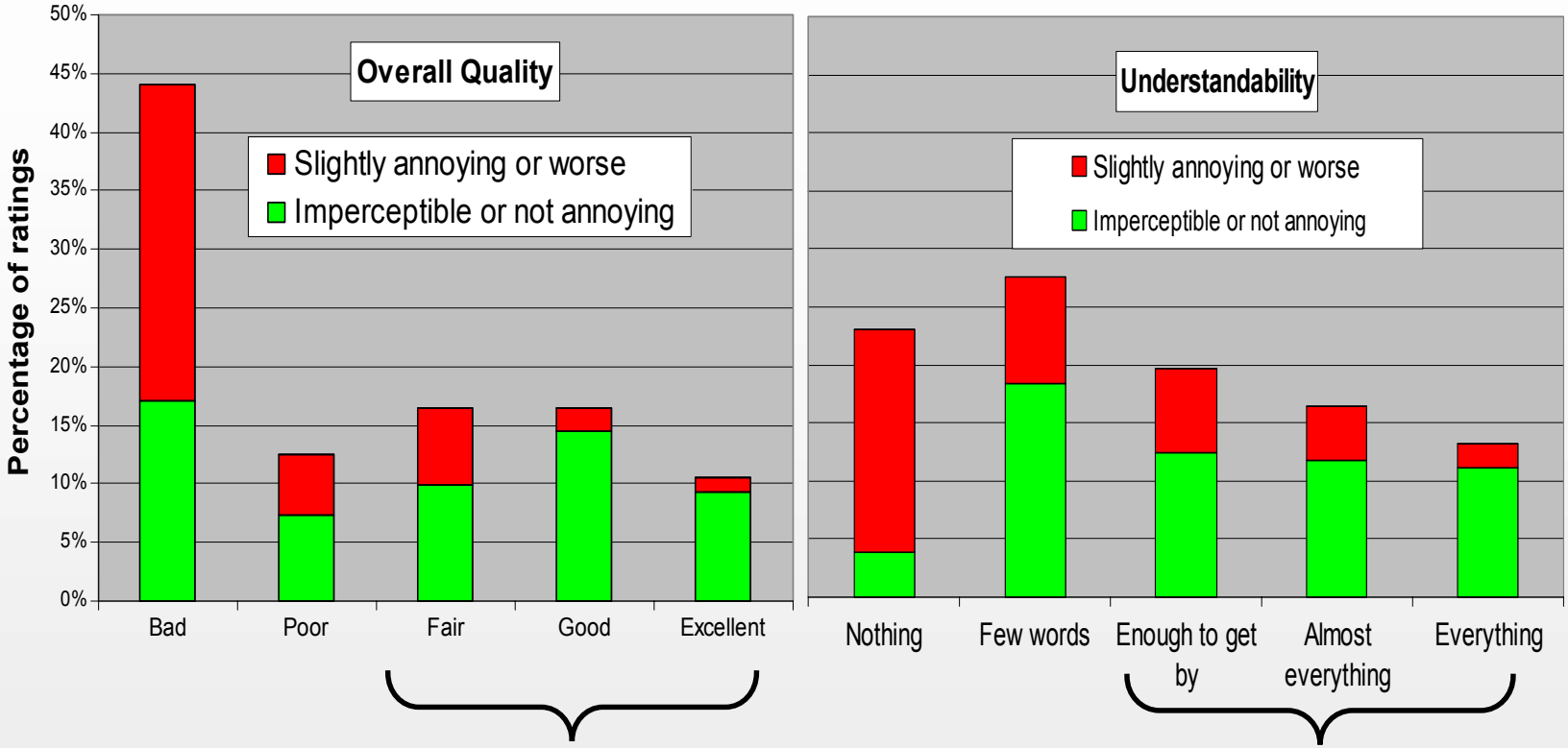
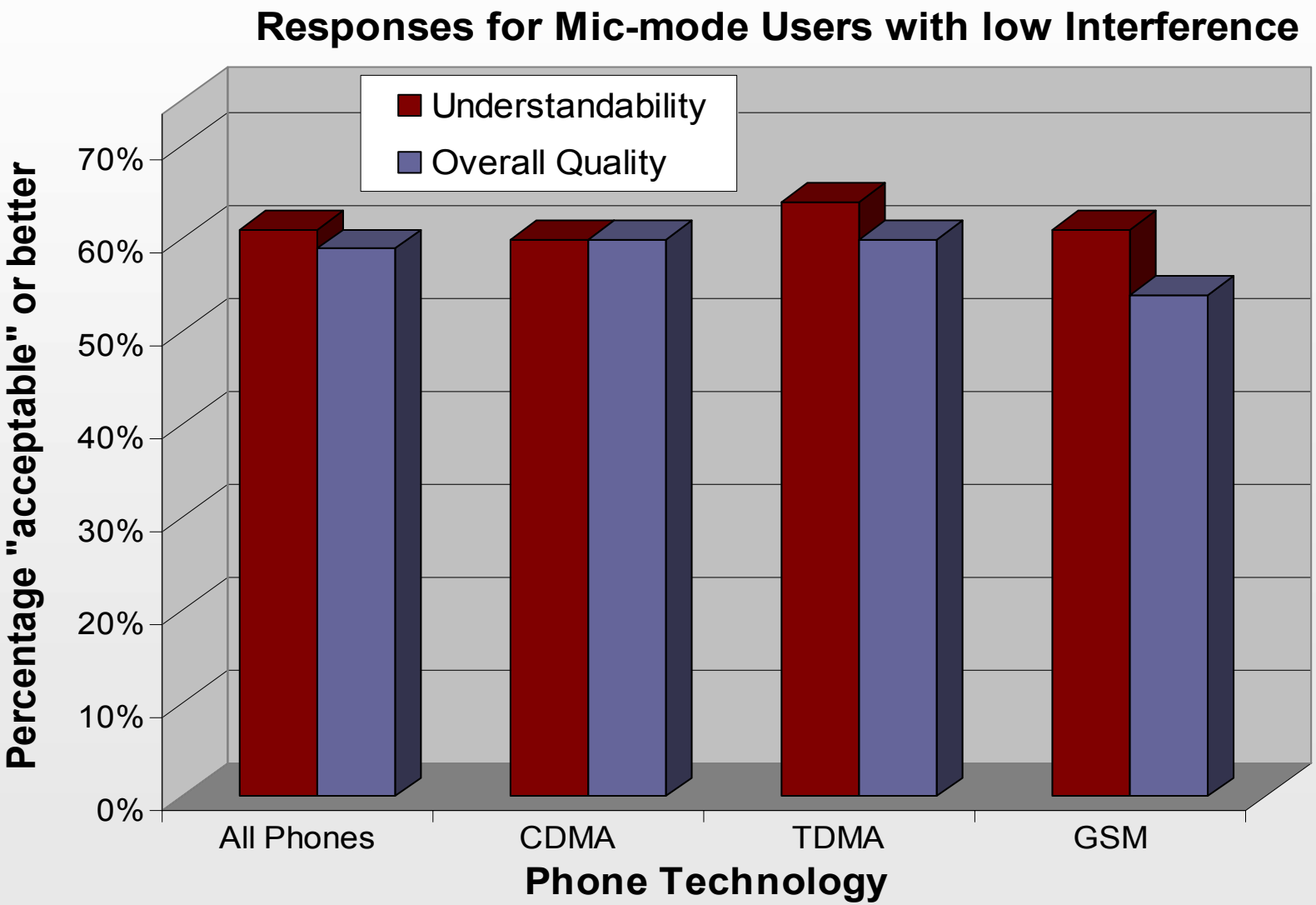
Some hearing aids performed well



About 60% of the mic-mode users who have <u>no annoying interference</u> (color-coded green), have an "acceptable" experience (defined as Understandability and Overall Quality ≥ 3).

Hearing aids with positive results spanned all technologies



Relation of ANSI C63.19 to Subjective Results: 1

1. The Overall U-Level rating does not correlate with any of the subjective ratings.
   - Overall U-Level includes analog AMPS measures.
2. The digital (E1900MHz) U-Level ratings have some correlation with subjective rating of **Interference Noise**.
   - Strong evidence for additional, but unidentified, factors not included in C63.19 measurements.

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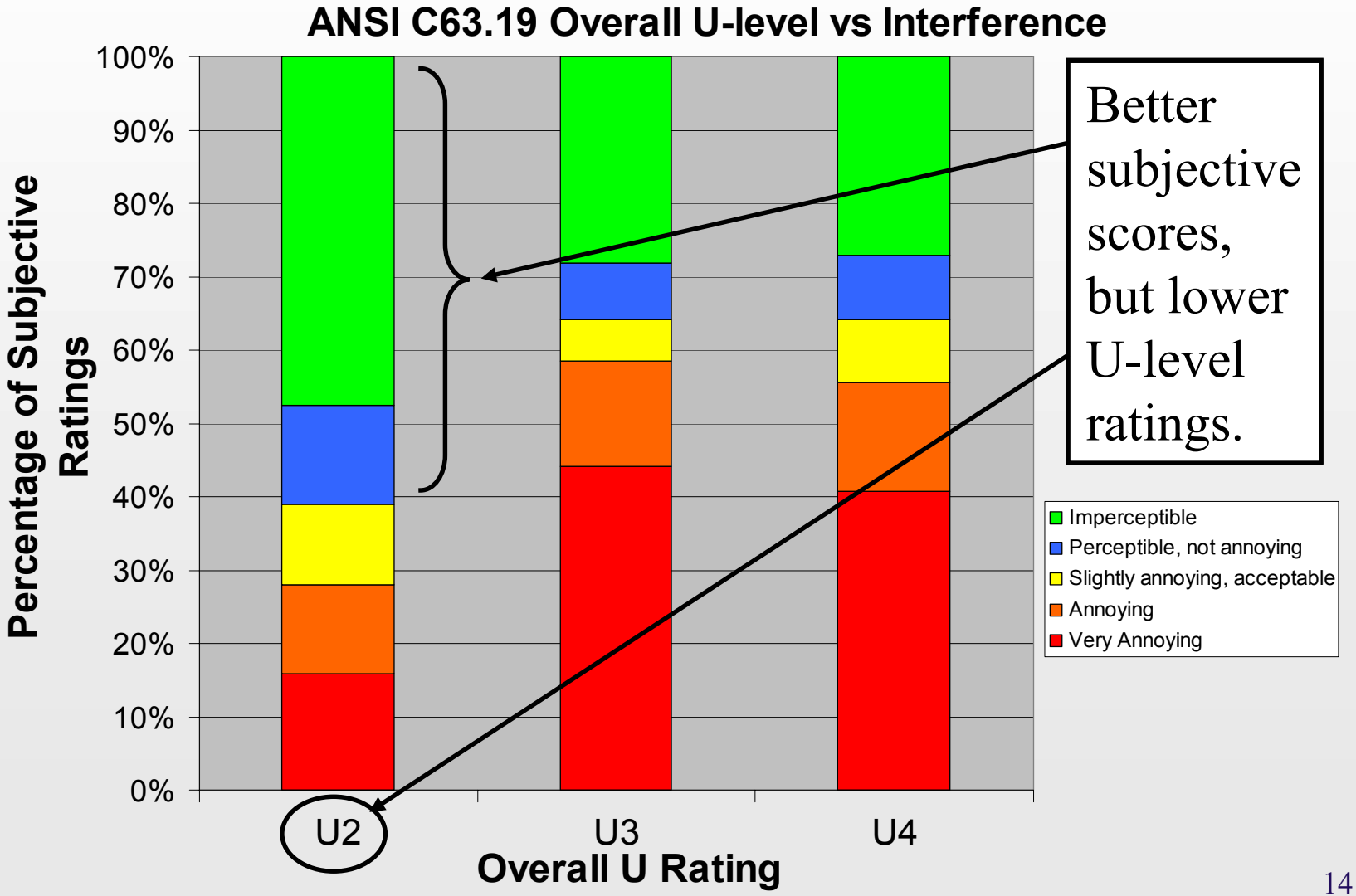
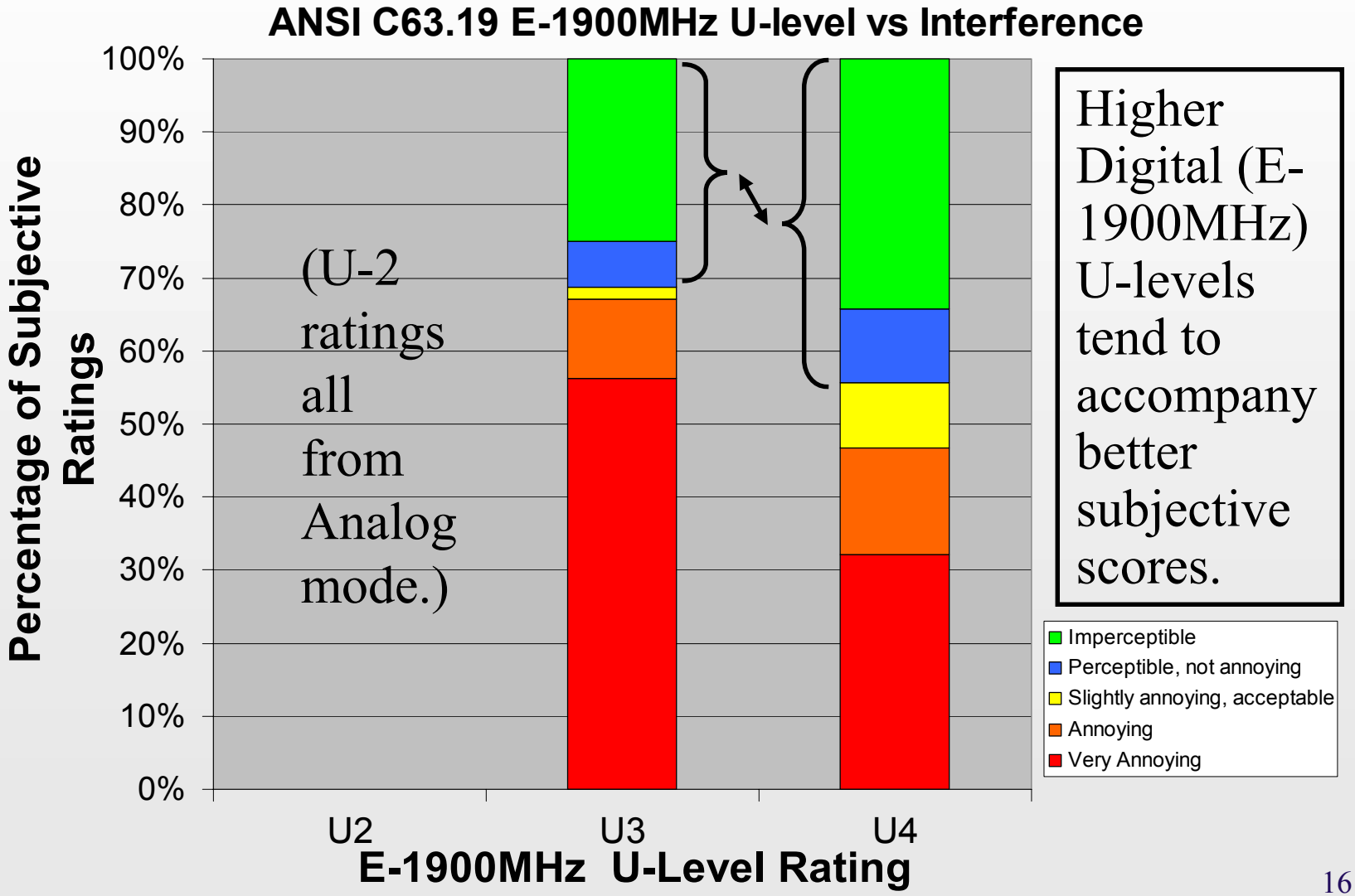
Relation of ANSI C63.19 Overall to Subjective Results



Relation of ANSI C63.19 to Subjective Results: 2

1. The Overall U-Level rating does not correlate with any of the subjective ratings.
   - Overall U-Level includes analog AMPS measures.
2. The digital (E1900MHz) U-Level ratings have some correlation with subjective rating of **Interference Noise**.
   - Strong evidence for additional, but unidentified, factors not included in C63.19 measurements.

Relation of ANSI C63.19 Digital to Subjective Results



Conclusions

- Two types of emissions impact hearing aid usability:
  1. Intentional cellular RF transmissions (electric and magnetic)
  2. Other emissions and fields (electric and magnetic)
- Some hearing aids performed very well, but others suffer significant interference even with phones that score well under C63.19.
- Analog mode measurements confound results and should not be required.

Suggested Further Steps

- Conduct research to:
  1. Assess what additional emissions and fields (beyond C63.19 factors) are significant sources of interference.
  2. Attempt to characterize these emissions and fields and identify their sources.
  3. Determine why some hearing aids appear to be largely immune to all of these sources.
- Eliminate measurement of analog mode measurement in C63.19.

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Appendix

Instructions for Participants

Instructions for Participants

We are interested in finding out what you think about the speech (and sound) quality of these phones. To do this, we'd like you to listen to several phones while a speech recording is played.

I will present several phones to you. Once I hand the phone to you, listen to a few sentences, then rate the phone on the following terms.

Please make your rating strictly based on the sound and speech quality of the phone, NOT on the appearance of the phone or any other factors, such as how much it costs.

Please look over this sheet now [give Definitions and Rating Scales to participant].

First, rate the **understandability** of the speech. Understandability means being able to tell what was said. If you were able to understand all the speech, please rate it a "5". If you could not understand any of the speech, please rate it a "1".

Second, rate the **background noise** (that is, other sounds other than the speech sound that you hear over the telephone). The background noise may be a buzz sound, or a hiss sound, or any other sound other than the speech. If you perceive background noise, please tell me what kind of noise you heard. If you heard more than one kind of noise, tell me. For your rating, please rate the most salient [obvious] or annoying background noise you heard.

Listening effort refers to how much you feel you have to pay attention in order to understand what was said. Please rate how much effort was needed to understand what was said, with a "5" indicated no effort and a "1" indicating a lot of effort.

Overall quality: Finally, take into account your overall experience with the overall sound quality of the phone and please rate this phone, with a "5" indicating excellent, and a "1" indicating bad.

Subjective Rating Definitions

Understandability: Refers to being able to tell what was said.

Background noise/buzz: Refers to any other sounds other speech that you hear on the telephone. For example, background noise could be a buzzing sound, or a hissing sound. Other noises are also possible.

Listening effort: Refers to how much you feel you have to pay attention in order to understand what was said.

Overall Quality: Refers to how good the quality of the sound on the phone is, based on both the speech and the background sounds.

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Subjective Rating Scales

Please rate the sound and speech quality of the phone as a phone for everyday use for the following terms:

Understandability	Understood everything; perfectly clear	Understood almost everything	Understood enough to get by	Understood a few words	Didn't understand anything
	5	**4**	**3**	**2**	**1**
Background noise/Buzz	Imperceptible	Perceptible, but not annoying	Slightly annoying, but acceptable	Annoying, but could use it in a pinch	Very annoying; repels me
	5	**4**	**3**	**2**	**1**
Listening Effort	Complete relaxation possible; no effort required	Attention necessary, but not much effort needed	Moderate effort needed	Considerable effort needed	Didn't understand anything even with effort
	5	**4**	**3**	**2**	**1**
Overall Quality	Excellent	Good	Fair	Poor; Marginal	Bad; Unacceptable
	5	**4**	**3**	**2**	**1**