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Effect of speech on performance – an evidence-based model promoting noise control in offices

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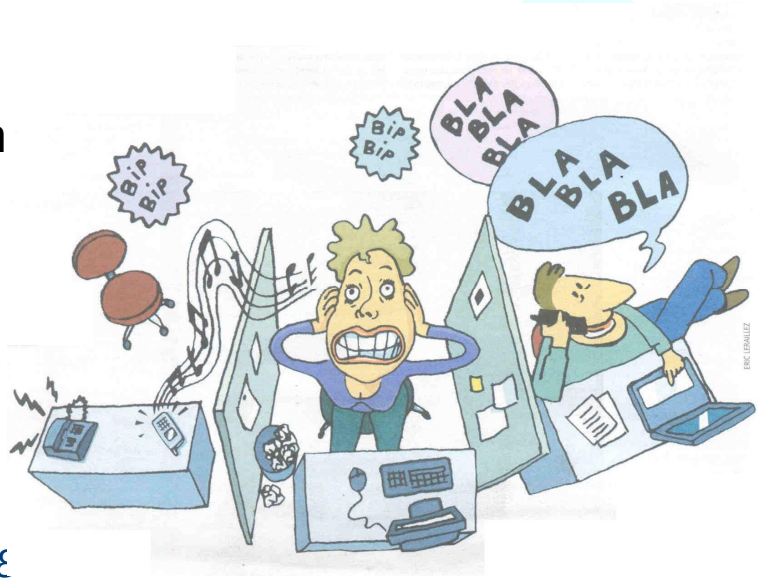
Background

- According to several independen field surveys, noise is the most adverse factor of IE in open-plan offices.
  - Frontzcac et al 2012 *Indoor Air*
- Speech is the most distracting type of office noise
  - *Haapakangas et al. ICBEN 200*
- Laboratory experiments have shown that speech impairs the performance of cognitively demanding tasks
  - Colle and Welsh 1976 J Verbal Learn Verbal Behav
  - Vast number of successors; see review by Hongisto 2005 Indoor Air



- Speech intelligibility determines the distracting power of speech primarily, not the sound pressure level of speech.
  - Colle 1980 J Verbal Learn Verbal Behav

- A well-documented objective descriptor of subjective speech intelligibility is STI
  - IEC 60268-16
  - Houtgast&Steeneken 1985 J Acoust Soc Am

- **Could we explain the performance effects of speech in such the terms of engineering so that these findings could benefit noise control in open-plan offices?**

Background

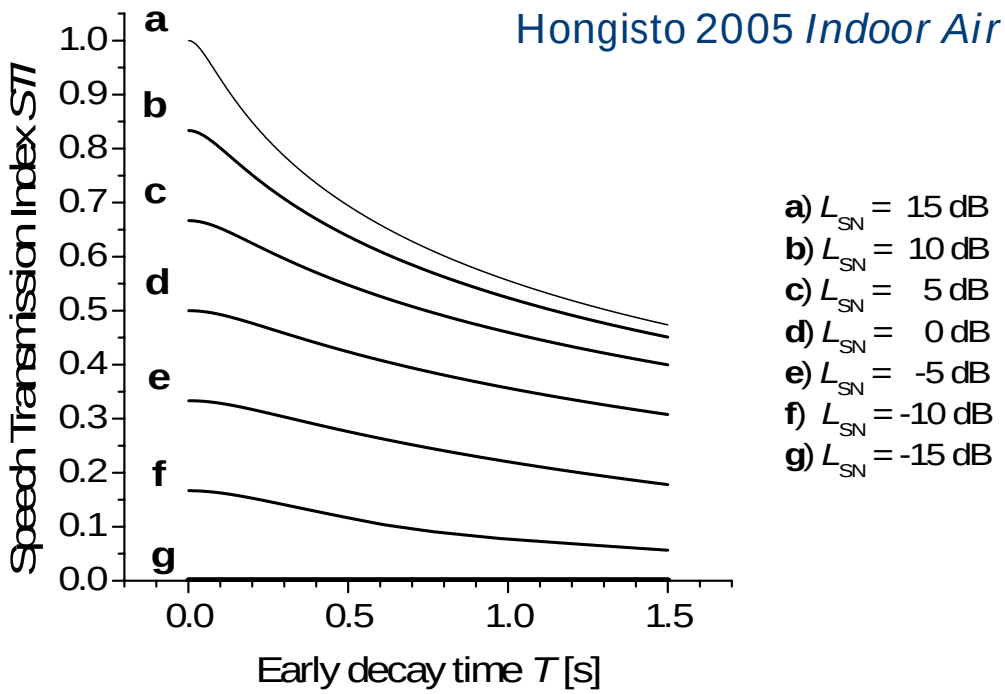
Frontzcac et al, *Indoor Air* 2012

52.920 occupants in 351 buildings
U.S. Offices
2000-2010

STI

- STI can be reduced by
  - reducing speech-to-noise ratio
    - Increasing background level
    - Reducing speech level
  - increasing reverberation time (EDT)

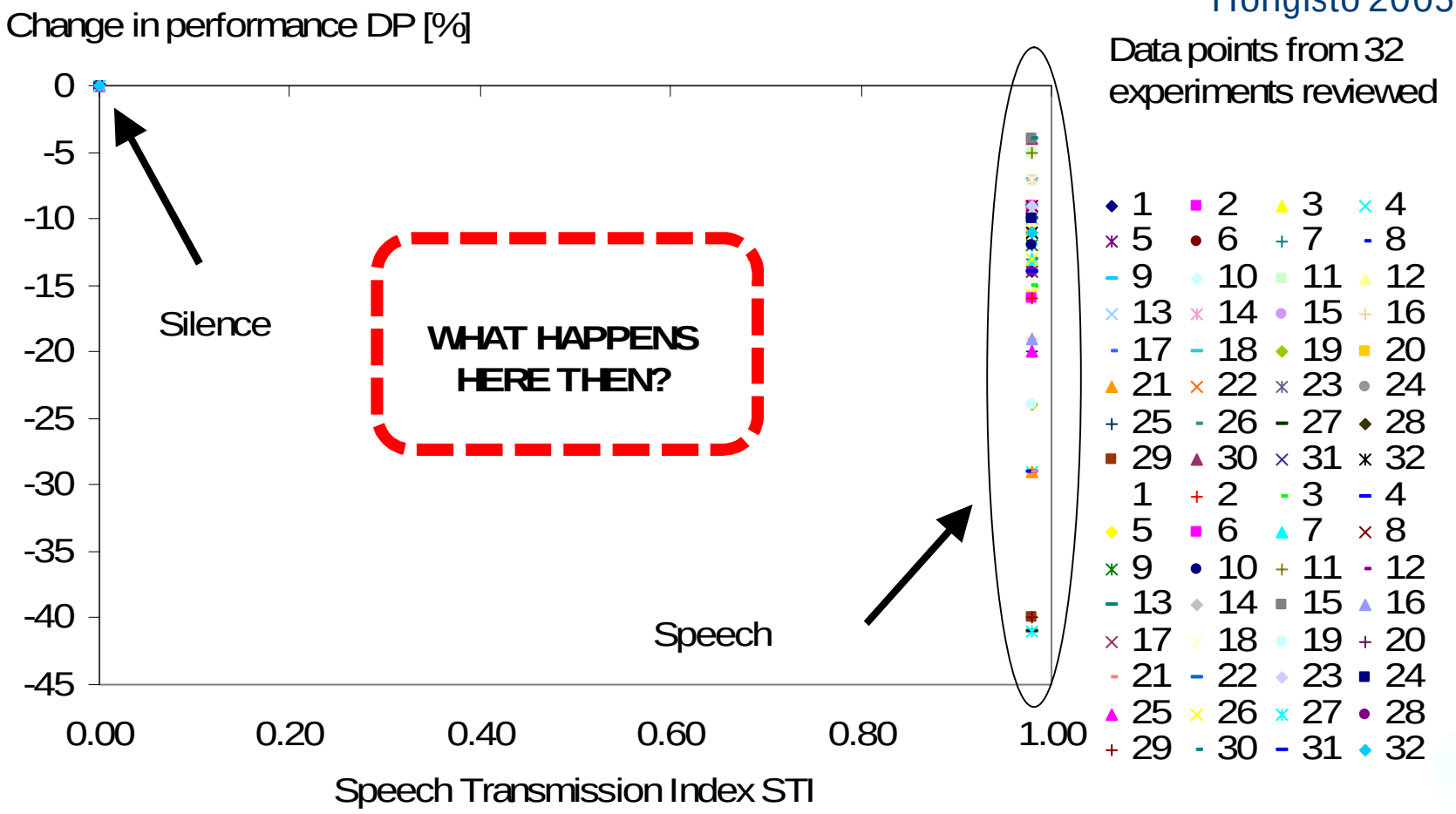
Hongisto 2005 *Indoor Air*



STI	Speech intelligibility	Speech privacy	Examples in offices
0.00 ... 0.05	very bad	confidential	Between two single-person office rooms, high sound insulation
0.05 ... 0.20	bad	good	Between two single-person office rooms, normal sound insulation
0.20 ... 0.40	poor	reasonable	Between workstations in a high-level open-plan office
			Between two single-person office rooms, doors open
0.40 ... 0.60	fair	poor	Between desks in a well designed open-plan office
0.60 ... 0.75	good	very poor	Between desks in an open-plan office, reasonable acoustical design
0.75 ... 0.99	excellent	no	Face-to-face discussion, good meeting rooms
			Between desks in an open-plan office, no acoustical design

Review of experimental work prior to 2004

Hongisto 2005 *Indoor Air*



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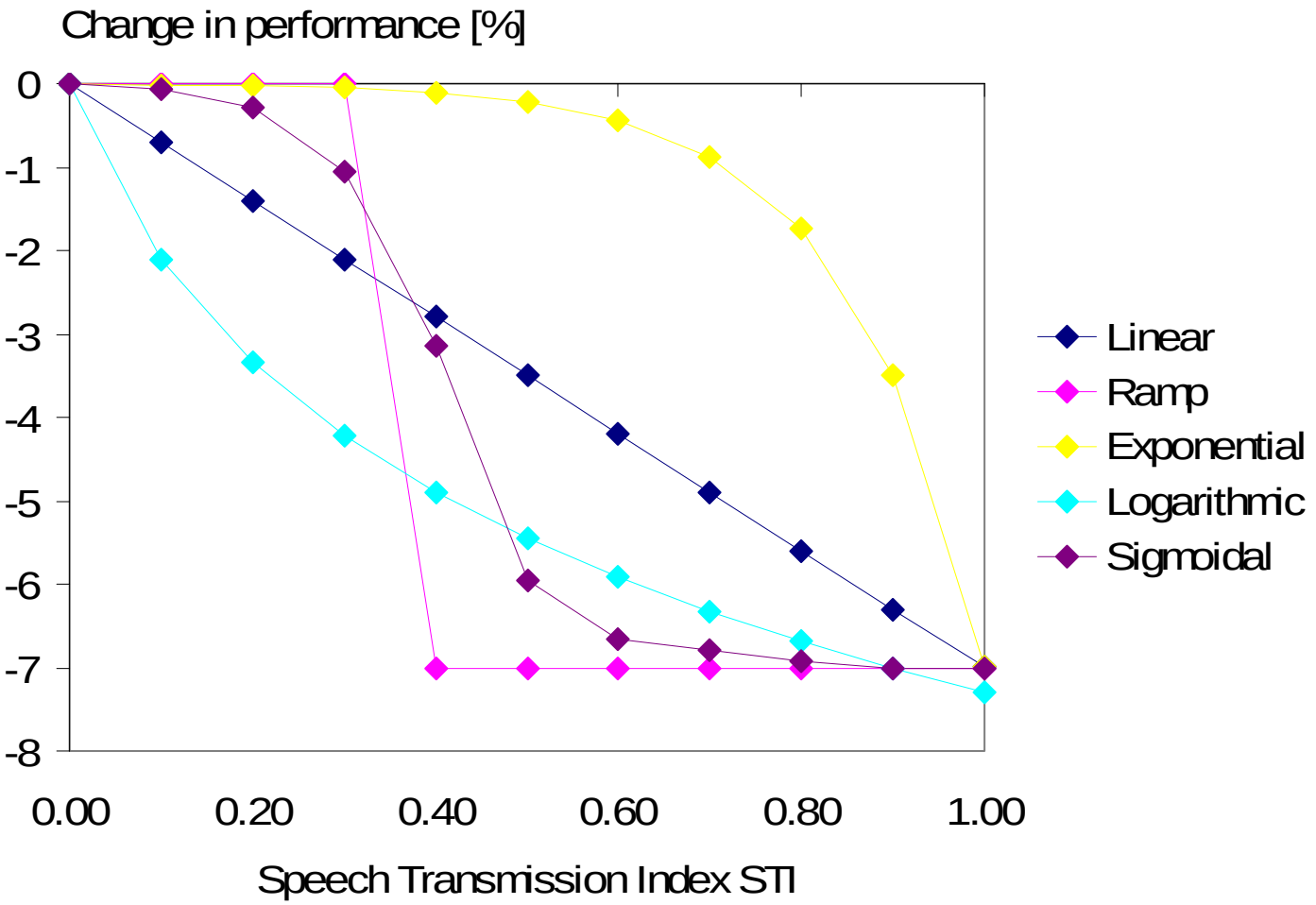
Alternatives of functional shapes



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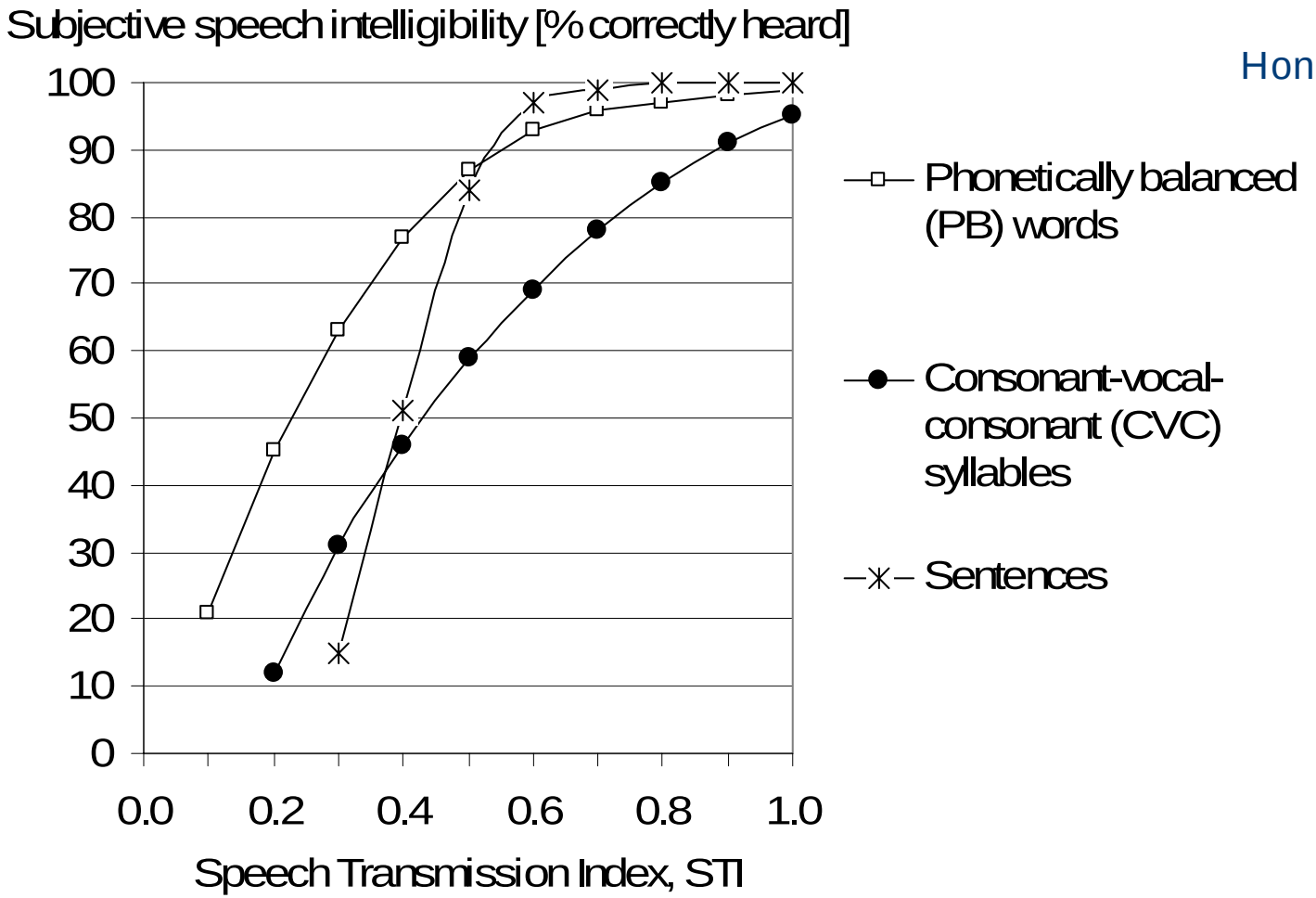
Dependence of subj. intelligibility on STI

Hongisto 2005 *Indoor Air*



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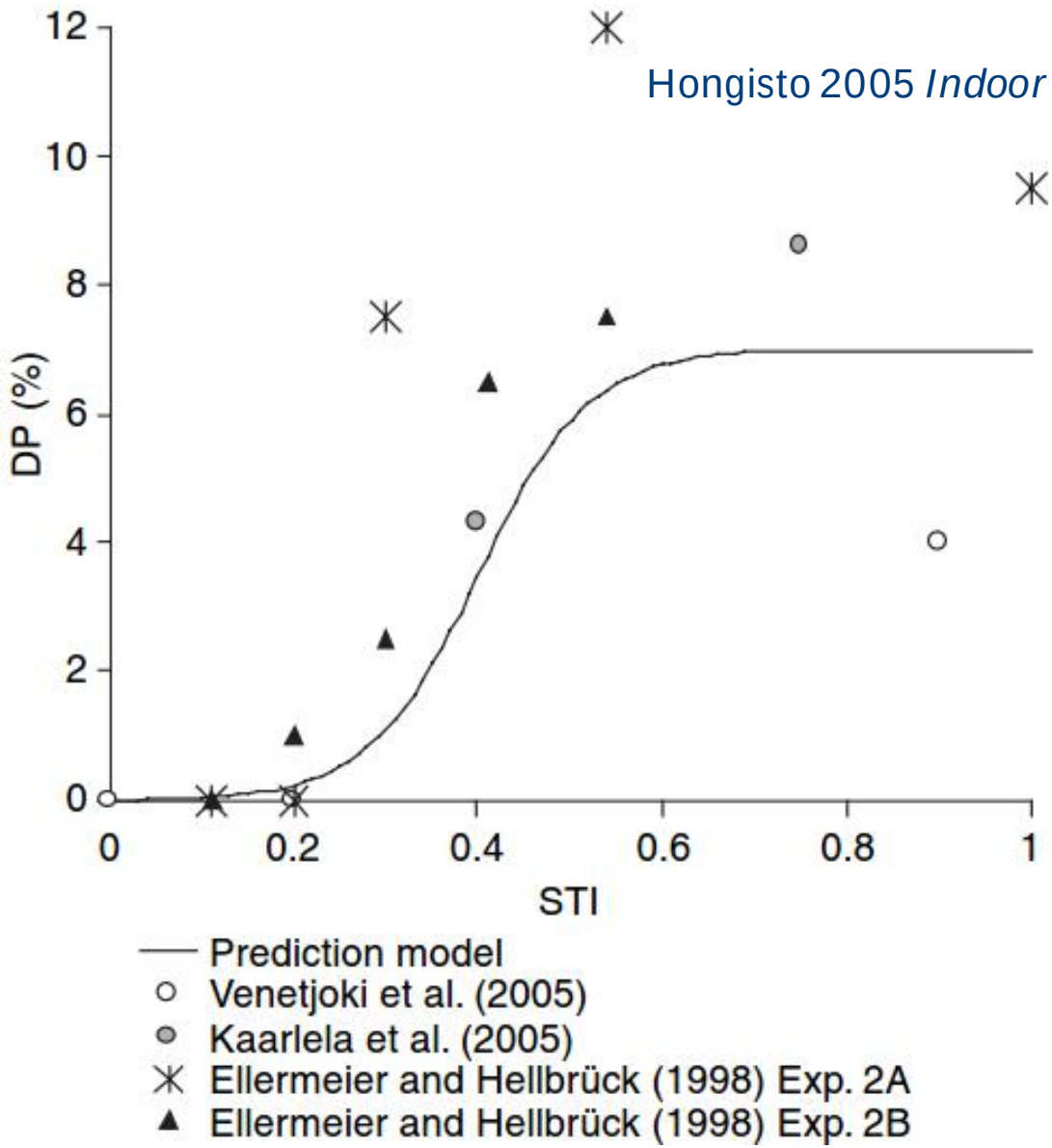
Original model

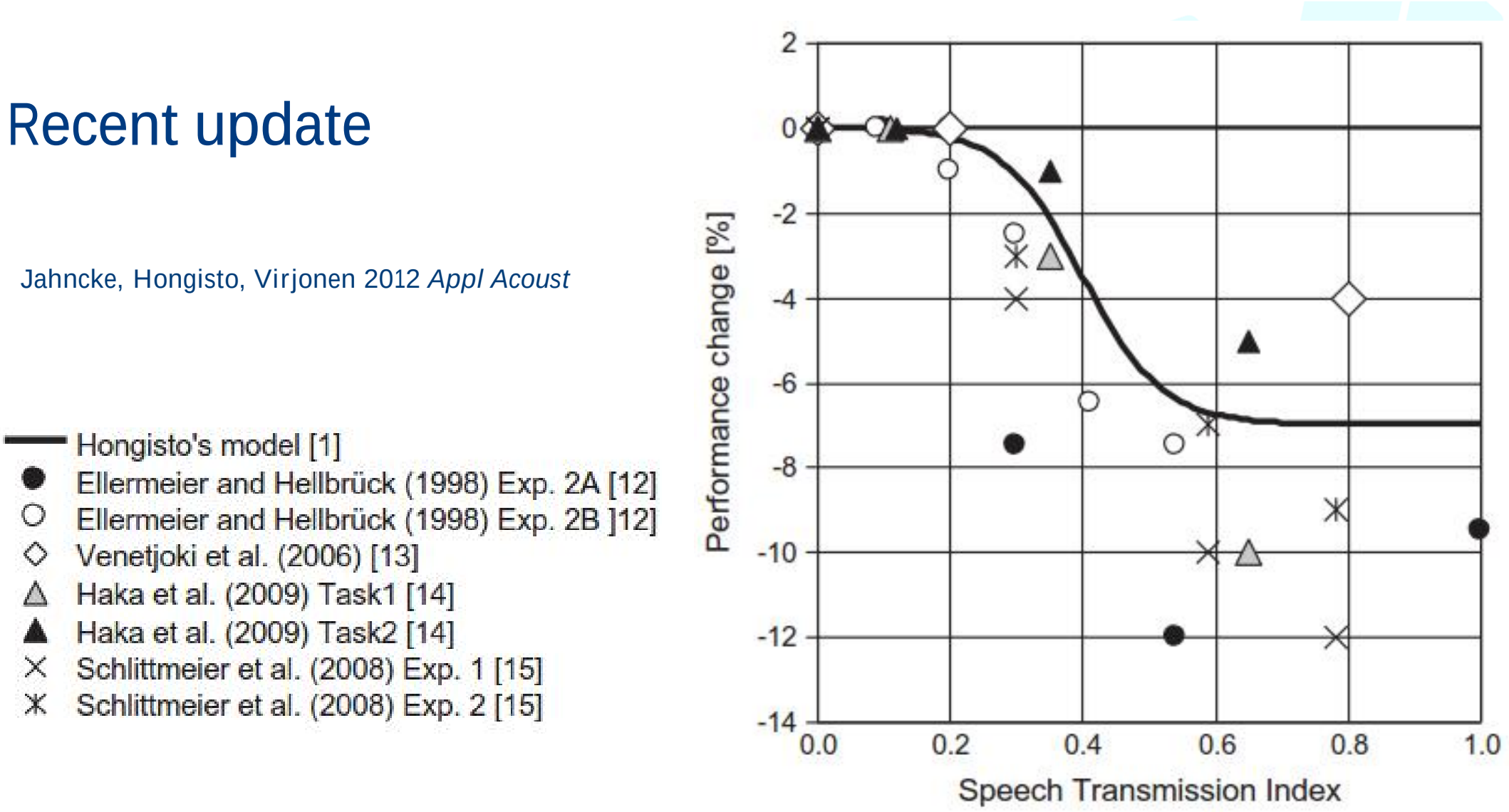
- Hypothetic model
  - Speech intelligibility vs. STI curve is applied for performance loss
  - Various task types are combined
  - Lack of data
- Perfect performance when STI below 0.20
- Max. performance loss is achieved when 0.50

Hongisto 2005 *Indoor Air*



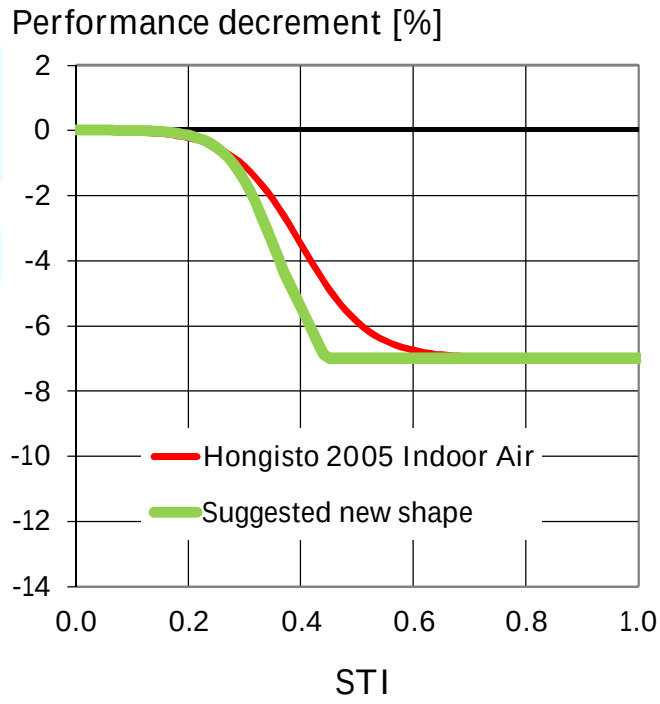
Recent update

Jahncke, Hongisto, Virjonen 2012 *Appl Acoust*



Recent experimental work

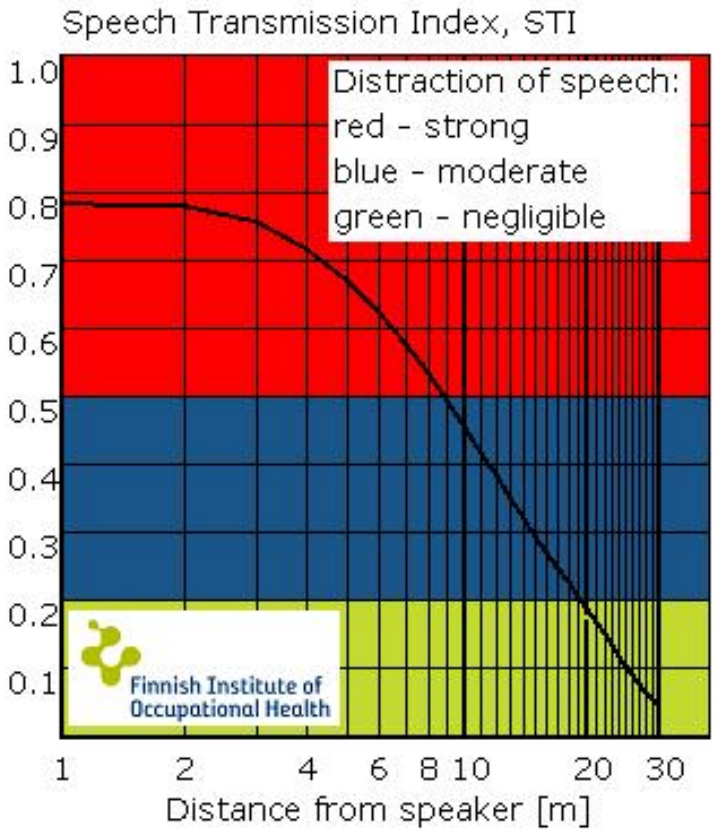
- More or less support has been given to the model
  - Keus van de Poll 2014 *Appl Acoust*
  - Ebissou et al 2015 *Appl Acoust*
  - Jahncke et al. 2012 *Appl Acoust*
  - Schlittmeier and Liebl 2015 *Facilities*
  - Hongisto et al. 2015 *(Published in Finnish)*
- A more general model also exists
  - Schlittmeier et al. 2012 *Atten Percept Psychophys*
  - Working memory performance as a function of fluctuation strength



- True shape may not be sigmoidal but steeper
- The exact form of the model may never be found
  - Type of task, type of speech, other factors
- **Nevertheless, the detriments of irrelevant speech can be controlled by reducing STI**

Application

- STI was could be proven to be such an important objective quantity that it should be measured in open-plan offices
- STI was chosen to ISO 3382-3:2012
  - Acoustics – Measurement of room acoustic parameters. Part 3. Open-plan offices
- STI of normal effort speech is measured as a function of distance, as well as the SPL of speech
- Distraction distance r_D is the distance where STI falls below 0.50.



RESULTS

DL2:	9.3 dBA
rD:	8.0 m

○ A-weighted speech level

◉ Speech Transmission Index

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Global promotion of noise control

- 2007: ICA preliminary method
- 2008: First national guidelines for rD and D_{2S} in Finland
- 2012: ISO 3382-3 in 2012
- 2010: Numbers of cross-sectional studies have emphasized the noise problem in open-plan offices

- Research in the area is still growing – Health aspects have received larger interest
- Business possibilities of acoustic consultancy has increased
- Room acoustic models and measurement apparatus have improved w.r.t. new compact features needed in open-plans
- Material manufacturers disseminate the r&d evidence to improve their business