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# Auditory dysfunction associated with solvent exposure

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100 YEARS AHEAD

# Background

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## Occupational hearing loss

- One of the most prevalent occupational disorders largely due to excessive noise
  - Approximately 10 million of Americans suffer from noise-induced hearing loss
- Certain chemicals in the workplace cause hearing loss independent of noise exposure

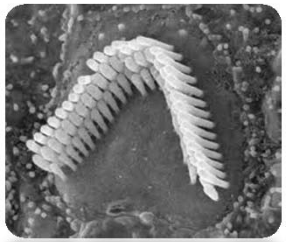
# Background

- Organic Solvents
  - Toluene
  - Styrene
  - Xylene
  - *N*-hexane
  - TCE: trichloroethylene
- Heavy Metals
  - Lead
  - Mercury

# Background -Animal studies

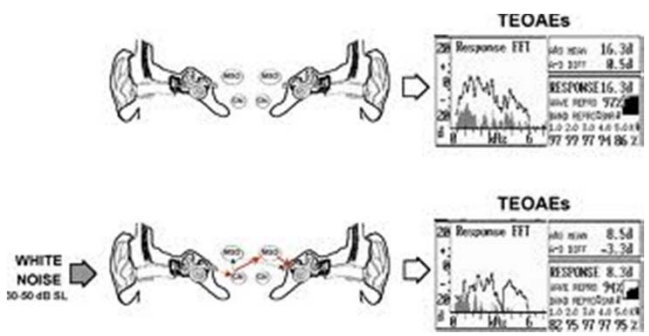
- The damage caused by solvents such as toluene in its early stages occurs in the first row of OHCs and then toward the second and third row.

- The mid-range frequencies are affected first, and according to some authors the damage continues toward the apical zone of the cochlea (Campo et al., 1997; Johnson & Canlon, 1994).



# Background -Animal studies

- Recently toluene was shown to act on the auditory efferent system and thereby inhibit the acoustic protective reflexes in the rat.
  - Occupational exposures to toluene were associated with increased acoustic reflex decay (Morata et al., 1993).



# Background -Human studies

- Studies in humans have demonstrated hearing loss induced by solvent exposure (Szulc-Kuberska et al., 1976; Morata et al., 1997)

- Some studies have also suggested central damage induced by solvents (Laukli & Hansen, 1995; Moen et al., 1999)

# SOLVENTS



**Dysfunction on the Peripheral Auditory System**

**Dysfunction on the Central Auditory System**

Evidenced by

**Elecrophysiological Measurements:**

- **A.B.R**
- **Late latency auditory evoked Potentials**
- **Cortical Response Audiometry**

**Behavioural Auditory Processing Tests:**

- Interrupted Speech
- Filtered speech
- Dichotic stimulation

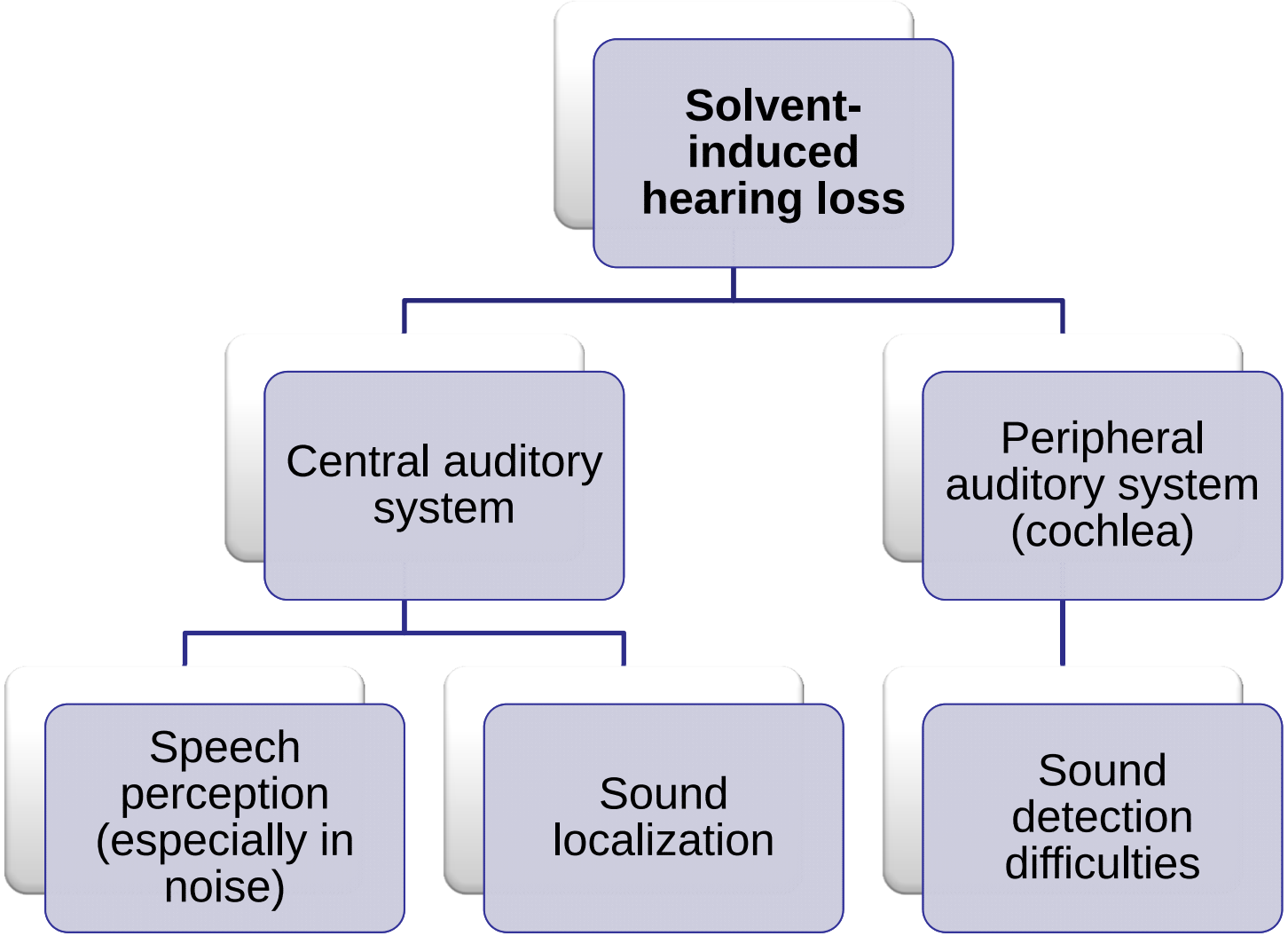
**Mix tures of Solvents**

**Toluene**

**Carbon Disulphide**

**Hearing Difficulties:**

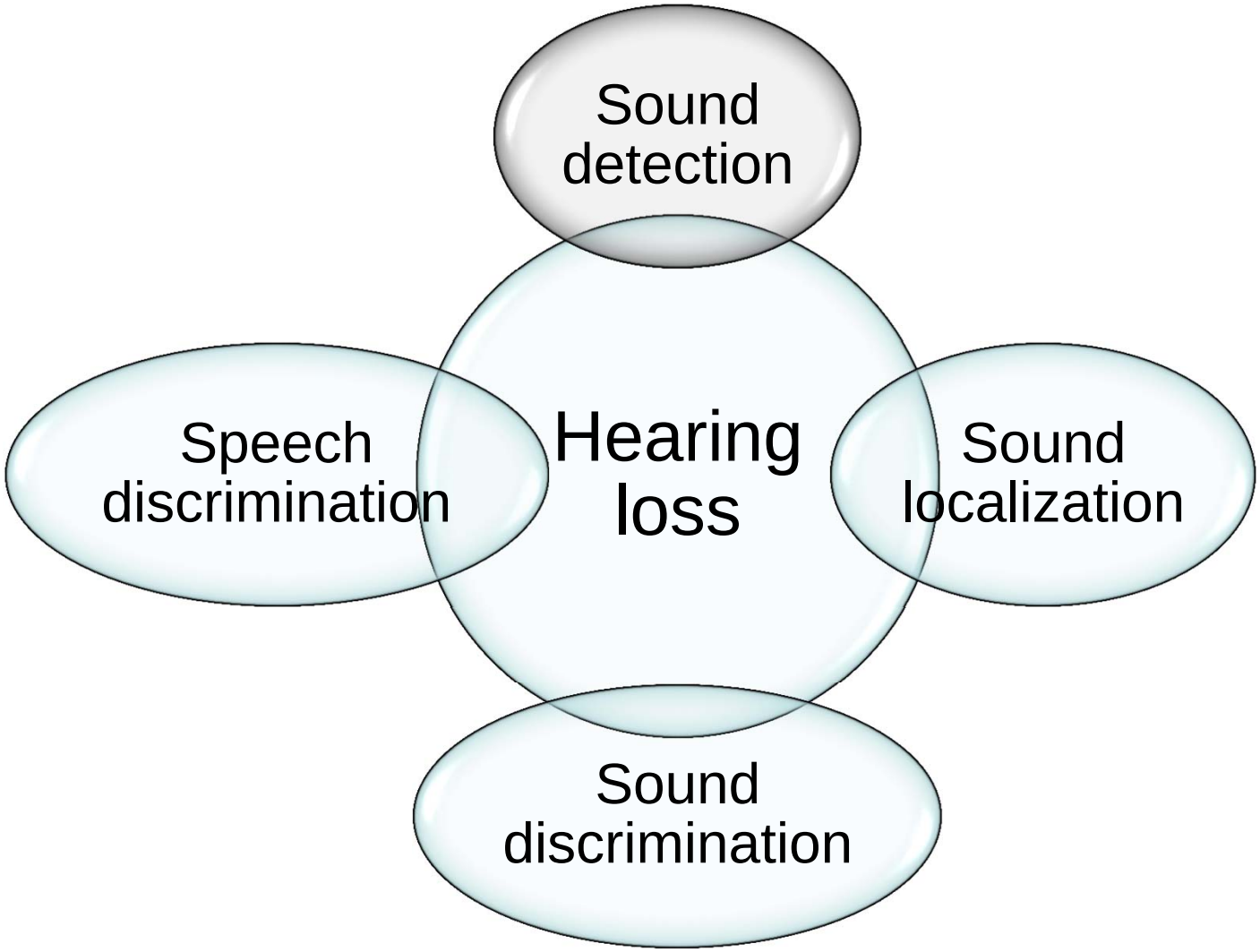
- Speech Discrimination, especially in the presence of background noise
- Sound Localization
- Sound Discrimination


Solvent-induced hearing loss
Central auditory system
Peripheral auditory system (cochlea)
Speech perception (especially in noise)
Sound localization
Sound detection difficulties

# Objective

The aim of this research was to investigate whether solvent-exposed workers report poorer hearing performance in daily-life activities, as related to the function of the peripheral and central auditory systems, compared to non-exposed subjects.

# Hearing Loss (WHO, 2001)



# METHOD

# Subjects

- 48 workers exposed to a mixture of solvents from paint making factories were selected as the study group. The mean age of this group was 38.6 years

- 48 gender, age and educational level matched subjects were selected as the control group. The mean age of this group was 36.8 years

# Sample selection procedures

- No visible alteration of the ear canal and tympanic membrane
- Pure-tone audiometry. Subjects exposed and non-exposed to solvents must have audiometric patterns associated with either normal hearing or sensorineural hearing loss
- Type A results for tympanometry

# Sample selection procedures

- No history of ear infections, medical conditions such as diabetes, kidney failure, high blood pressure, ototoxic treatment, or alcohol abuse (Morata & Little, 2002)

- Noise level not higher than 85 dB (A)

# Final sample

- The job categories among the selected workers included maintenance engineers, production supervisors, machine operators, quality controllers, assistants, mixers, and hazardous waste handlers.

- They were exposed to a mixture of solvents (mean length of exposure: 13.5 years) including **toluene** (mean: 14.3 mg/m3), **xylene** (mean: 28.2 mg/m3), **methyl ethyl ketone** (Mean: 10.8 mg/m3), and **white spirit** (mean: 116.3 mg/m3).

# Audiological test battery

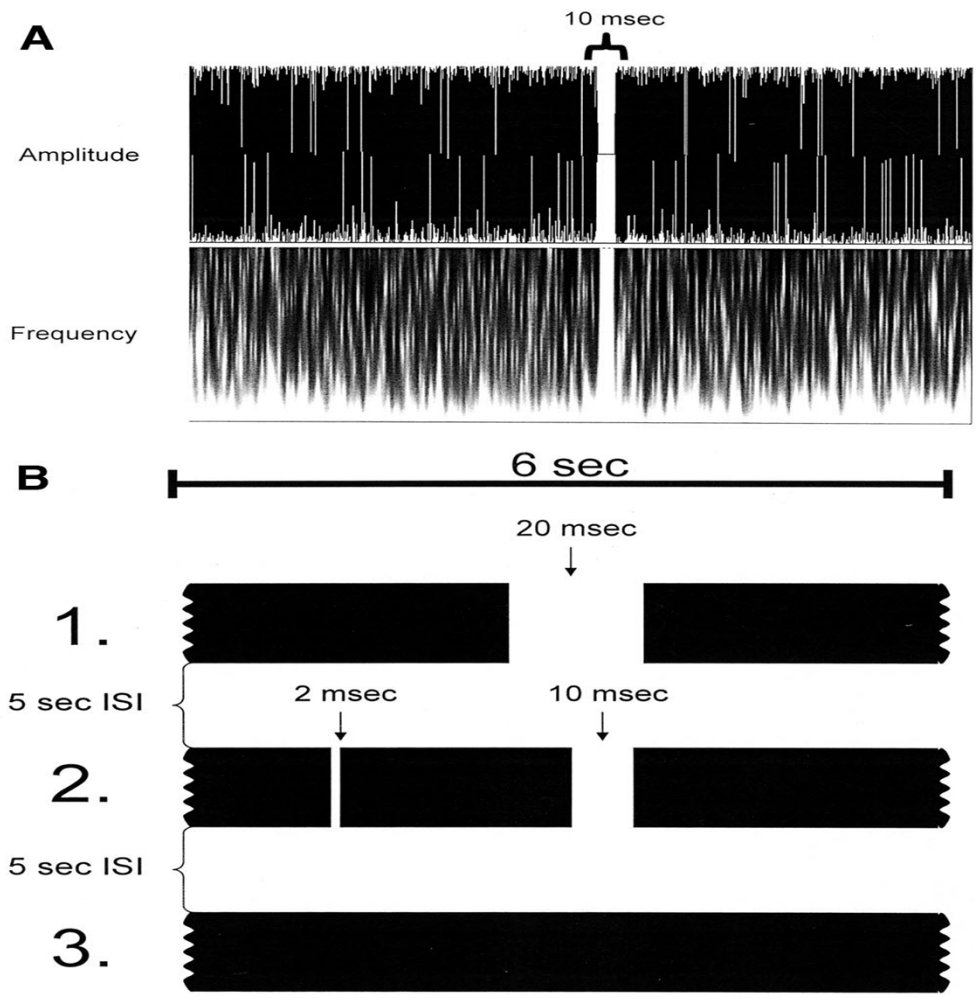
- Pure-tone audiometry (pure-tone hearing thresholds)
- Random gap detection (temporal resolution)
- Amsterdam Inventory for Auditory Disability and Handicap (self-reported hearing complaints )

# Random Gap Detection

- The RGD specifically explores temporal resolution, which is related to the timing encoded in the auditory fibres in response to sound.

- Temporal resolution has been indicated as one of the aspects of the central auditory nervous system that is adversely affected by solvent exposure.

# Temporal resolution



# Random Gap Detection

- Presentation of tone bursts
  - 500 Hz
  - 1000 Hz
  - 2000 Hz
  - 4000 Hz

- Presentation of clicks

# Amsterdam Inventory

- The AIADH is comprised of 30 question-items.

- Each question addresses a specific listening activity (e.g., understanding speech in a crowded shop, following a conversation among various speakers during dinner, following a telephone conversation).

# Amsterdam Inventory

- The response scale is scored from 1 (almost never) to 4 (almost always), thus the higher the score, the better the performance. The total score of the AIADH is 120.

1. Can you understand a shop assistant in a crowded shop?

O Never O Occasionally O Often O Always

# Amsterdam Inventory

- Factor analysis of the original version of the questionnaire showed the presence of five main factors, which were interpreted by the authors as five basic auditory disabilities:
  - distinction of sounds
  - intelligibility in noise
  - auditory localization
  - intelligibility in quiet
  - detection of sounds

# Therefore…

- By using this questionnaire, aspects relating to the function of the peripheral auditory system (i.e., sound detection) and central auditory system (i.e., speech discrimination, sound localization) can be explored.

# Basic hearing functions

| Hearing function (ICF WHO, 2001) | Factor structure of the AIADH |
|---|---|
| Speech discrimination | Intelligibility in quiet<br>Intelligibility in noise |
| Sound discrimination | Distinction of sounds |
| Sound detection | Detection of sounds |
| Sound localization | Auditory localization |

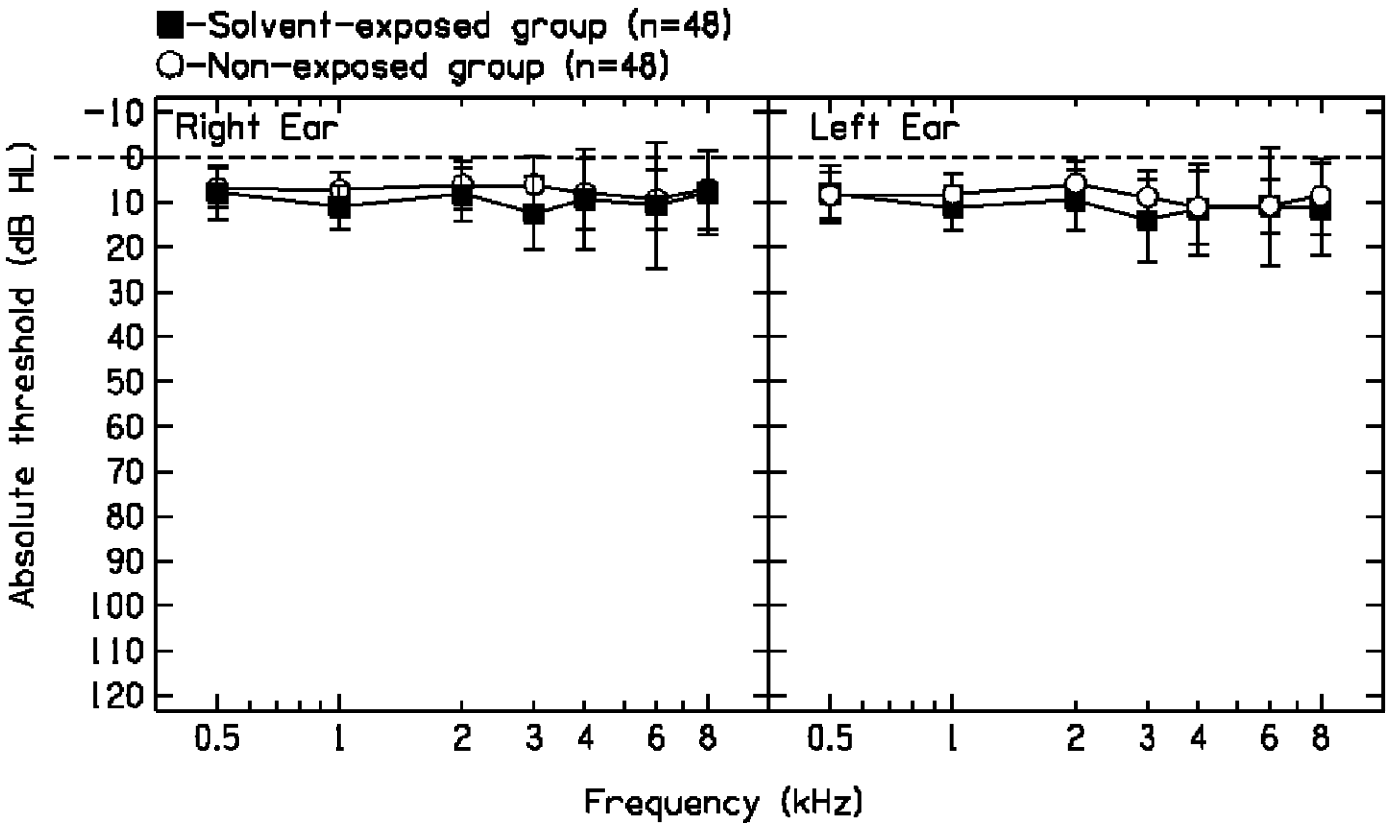
# Statistical analyses

- A Student t test and analyses of covariance (ANCOVA) were computed to determine possible significant differences between solvent-exposed and non-exposed subjects for the auditory outcomes.

- Pearson correlations among the three measures were also calculated.

# RESULTS

# Hearing thresholds –Left ear

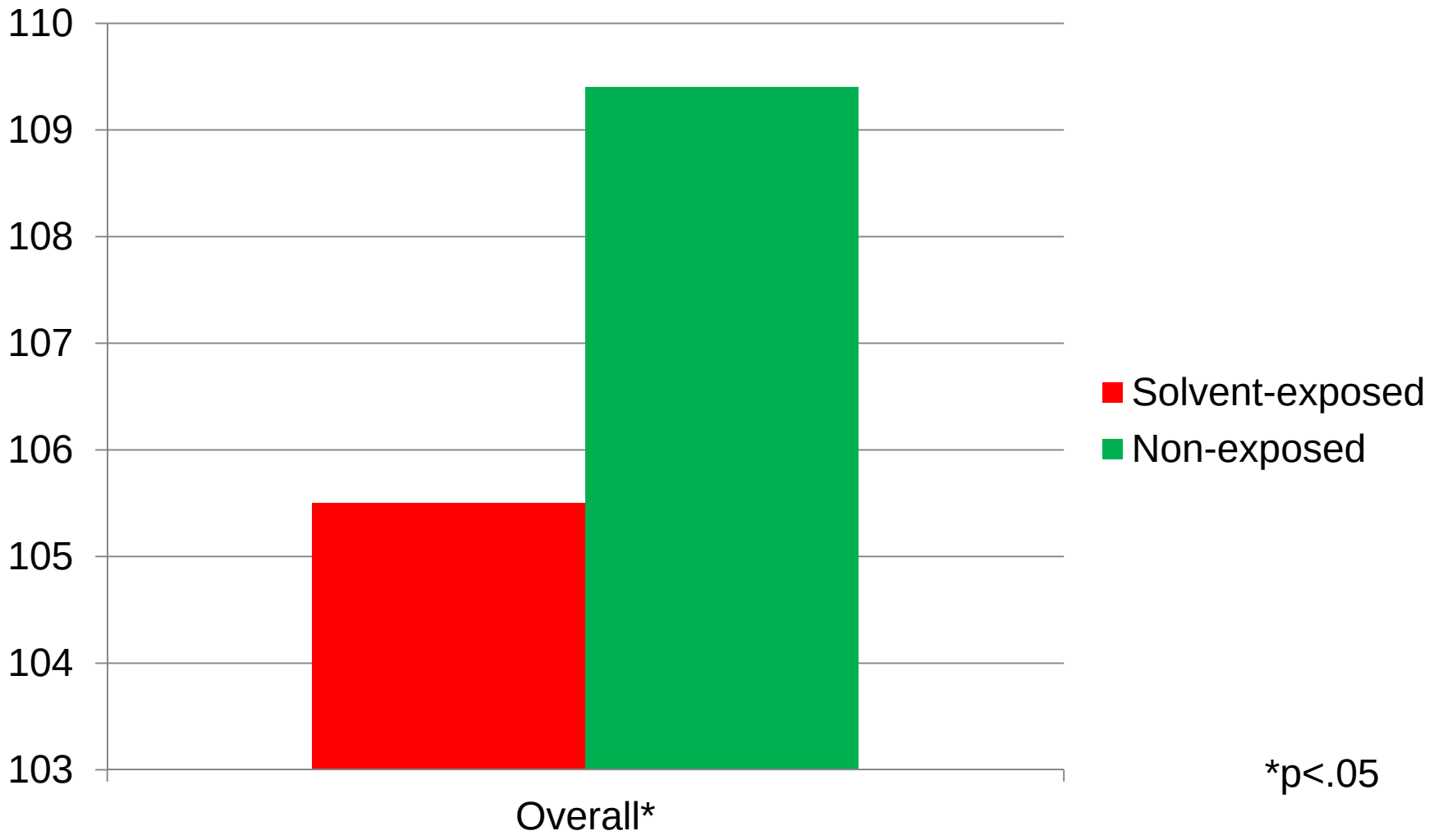


# Random Gap Detection

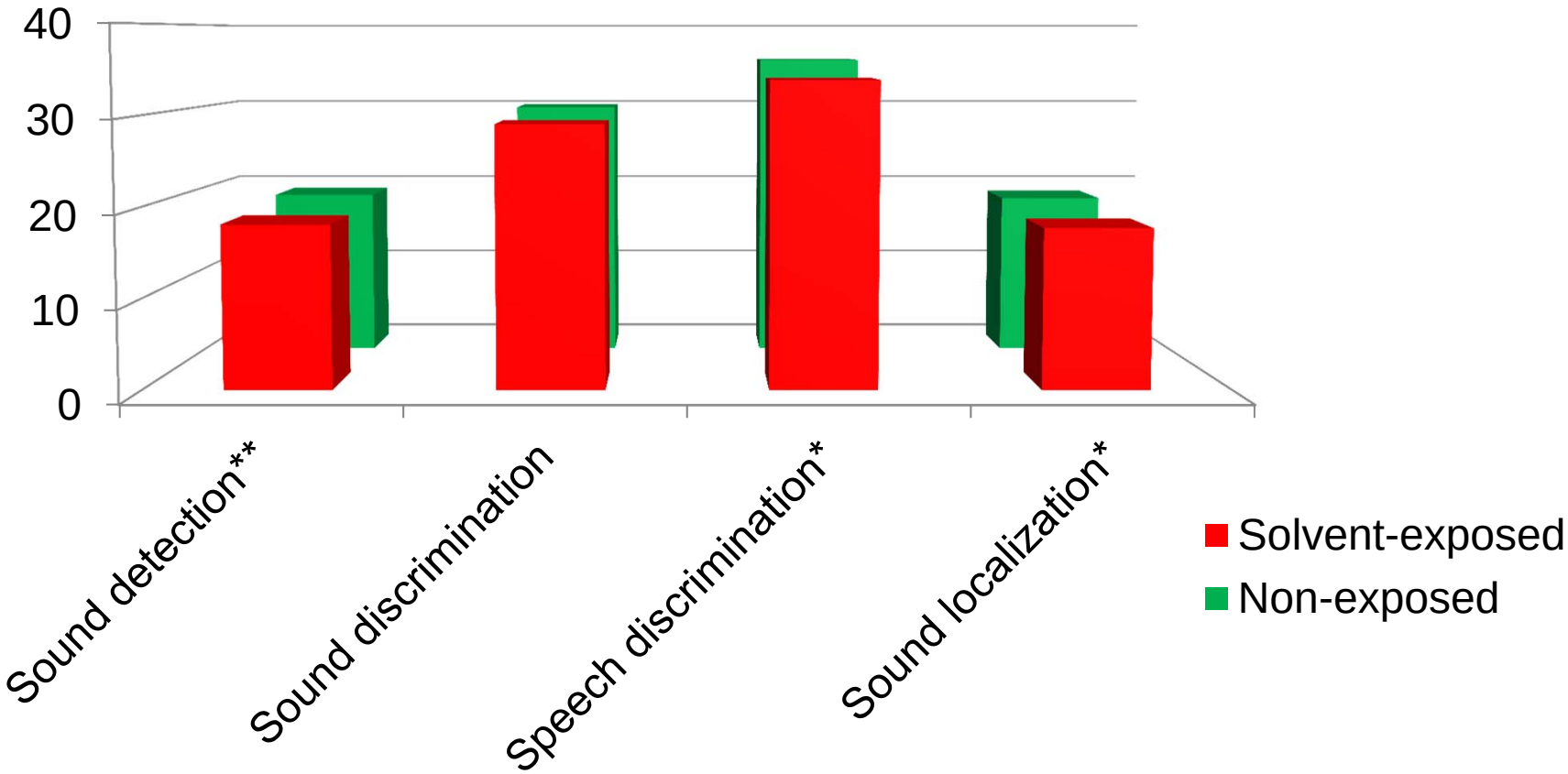

*p<.05
**p<.01

| | 500 Hz | 1000 Hz** | 2000 Hz | 4000 Hz** | Clicks* |
|---|---|---|---|---|---|
| Exposed | 14.1 | 12.3 | 15.6 | 15.3 | 10.5 |
| Non-exposed | 11.1 | 9.7 | 11.1 | 9.2 | 6.9 |

# Amsterdam Inventory



# Amsterdam Inventory




*p<.05
**p<.01

# Correlations

| | Pure-tone thresholds | Random Gap Detection | Amsterdam inventory |
|---|---|---|---|
| Pure-tone thresholds | * | | |
| Random Gap Detection | 0.17 | * | |
| Amsterdam Inventory | -0.21* | -0.24* | * |

*p<.05

# Summary

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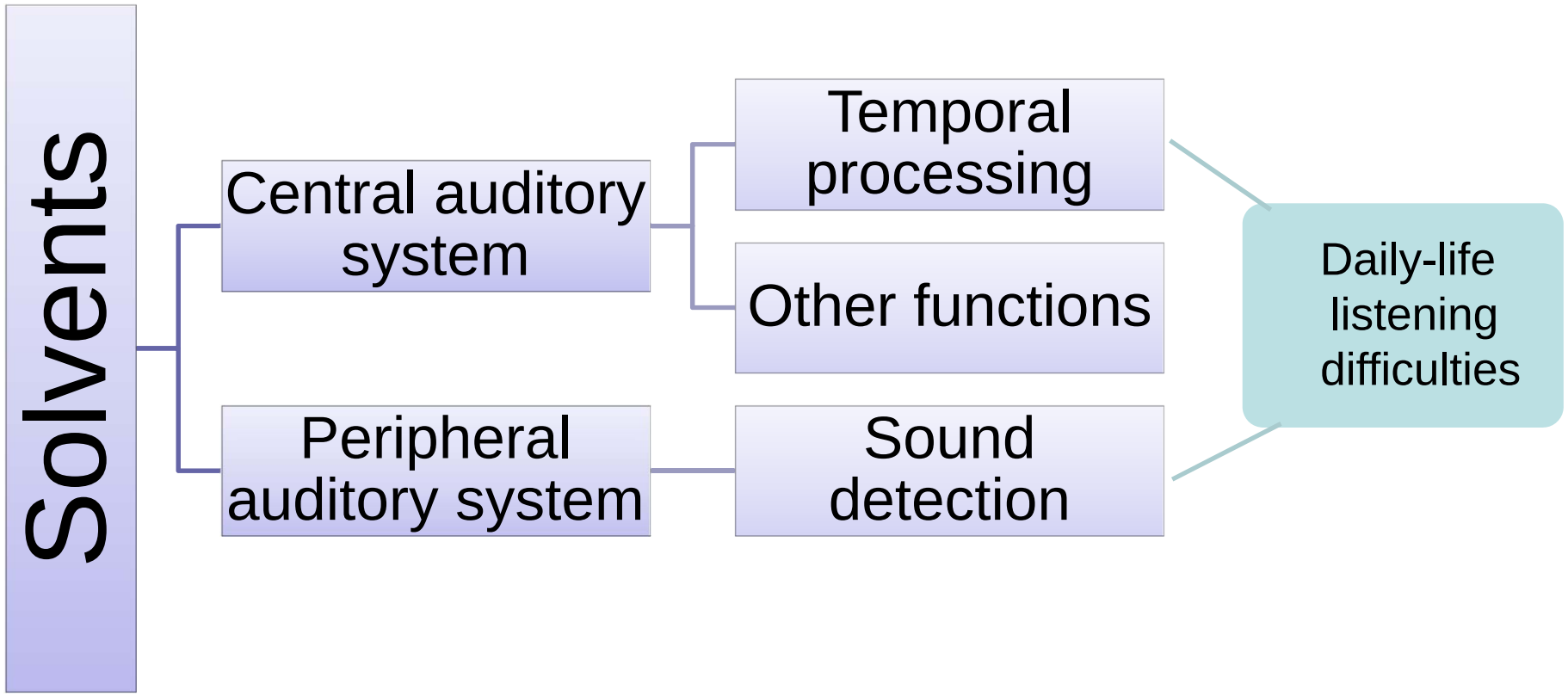
- Solvent-exposed workers exhibited poorer
  - Hearing thresholds
  - Temporal resolution
  - Self-reported hearing performance
  - Significant correlations between the overall score of the Amsterdam Inventory and pure-tone thresholds; and the Amsterdam Inventory and Random Gap Detection test

# Discussion

- Solvent-induced peripheral and central auditory function was found.

- Solvent-exposed workers encounter listening difficulties that relate to the function of the peripheral and central auditory systems


Solvents
Central auditory system
Peripheral auditory system
Temporal processing
Other functions
Sound detection
Daily-life listening difficulties

# Are we doing something about this?

# Take home message

- Solvent-exposed workers should be incorporated in hearing conservation programmes

- Solvent-exposed workers should be aware of the adverse effects of solvents on the auditory system

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# Thank you

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