INSTITUTET FÖR HANDIKAPPVETENSKAP

SWEDISH INSTITUTE FOR DISABILITY RESEARCH

Employees with aided hearing impairment – the effects of noise on working ability, cognitive skills and perceived disturbance

Håkan Hua

Björn Lyxell, Claes Möller & Stephen Widén

Background

- In Sweden 13.3% of the adult population (16-84 years), with or without hearing aids (HAs), report that they have difficulties following a conversation with more than two people involved (Statistics Sweden, 2007).

- Furthermore, Statistics Sweden (2003) reports that people with hearing impairment (HI) have an unfavorable position in the labor market. Around 835 000 people are currently working with a HI in Sweden.

- Research show that this group report bad health more frequently and estimate their own health to be worse than peers in their age group. Increased unemployment, early health-related retirement and sick leaves are also more common for people with hearing loss (Hetu, 1996; Danermark and Gellerstedt, 2004; Gellerstedt and Danermark, 2004; Kramer et al, 2006).

- Listening under adverse conditions is associated with increased PE for people with HI (Larsby et al, 2005; Rönnberg et al, 2008)

Studies

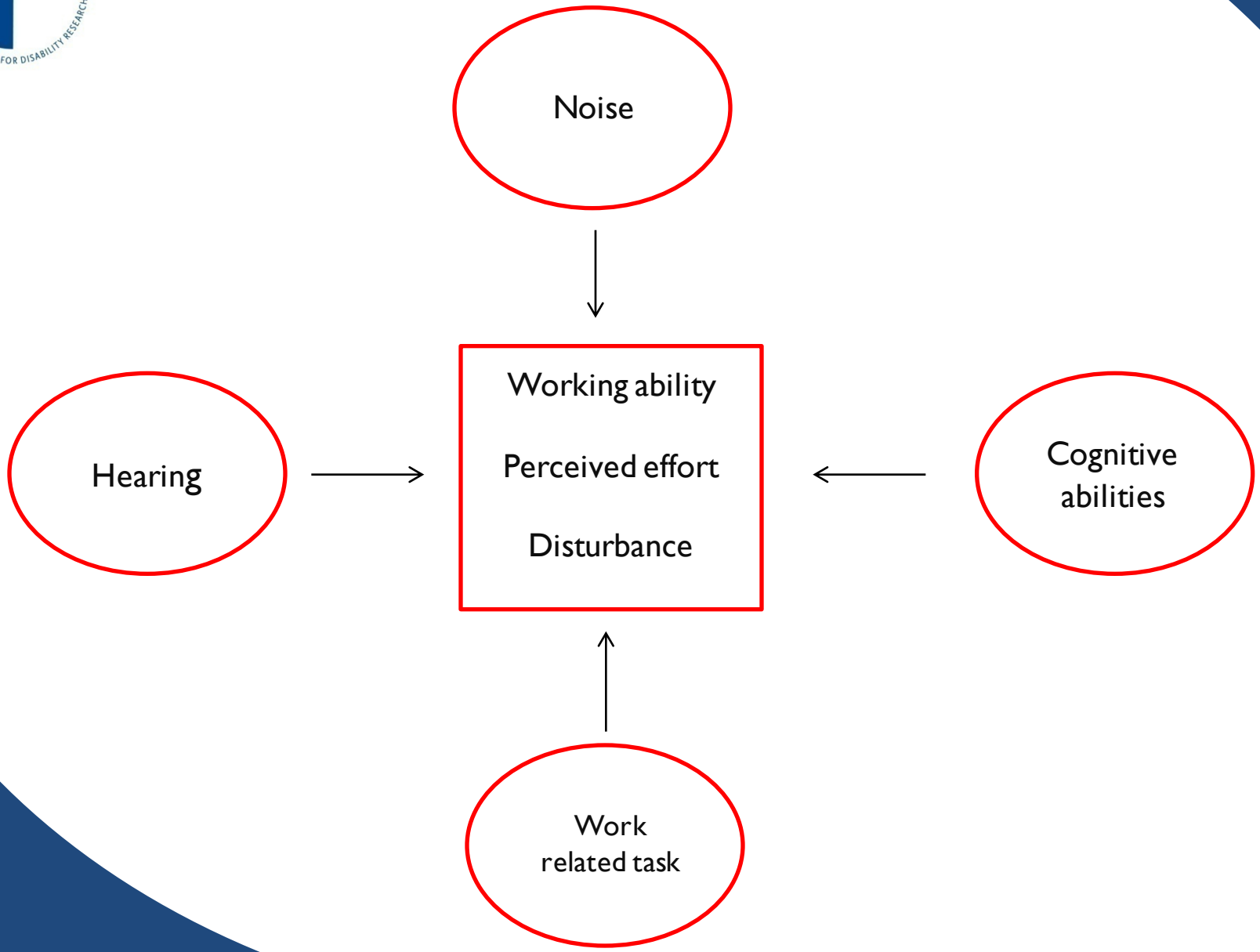
1. Hua H, Karlsson J, Widén S, Möller C, Lyxell B. (vol 52 iss 9) Quality of life, effort and disturbance perceived in noise: A comparison between employees with aided hearing impairment and normal hearing. *Int J Audiol*.

2. Hua H, Emilsson M, Ellis RJ, Widén S, Möller C, Lyxell B (vol 16 iss 69) Cognitive skills and the effect of noise on perceived effort in employees with aided hearing impairment and normal hearing. *Noise Health.*

3. Hua H, Emilsson M, Kähäri K, Widén S, Möller C, Lyxell B (vol 52 iss 9) The impact of different background noise: Effects on cognitive performance and perceived disturbance in employees with aided hearing impairment and normal hearing. *J Am Acad Audiol.*

4. Hua H, Anderzén AK, Widén S, Möller C, Lyxell B (vol 54 iss 11) Being part of the labor market – Conceptions among employees with aided hearing impairment. *Int J Audiol*.

Outline


Noise
Hearing
Working ability
Perceived effort
Disturbance
Cognitive abilities
Work related task

Material

- Forty participants (21 males) were recruited to the study.
- The hearing-impaired participants were selected based on the following criteria: age > 18 years, mild to moderate binaural sensorineural hearing loss and undergone aural rehabilitation. All participants in the hearing-impaired group were fitted bilaterally and had at least 3 months HA experience before the inception of the study.
- Exclusion criteria were: people who were retired due to age or with early retirement, people on long-term sick leave, and people with moderate-severe tinnitus, hyperacusis, psychiatric illnesses, dyslexia and other diseases/disabilities.

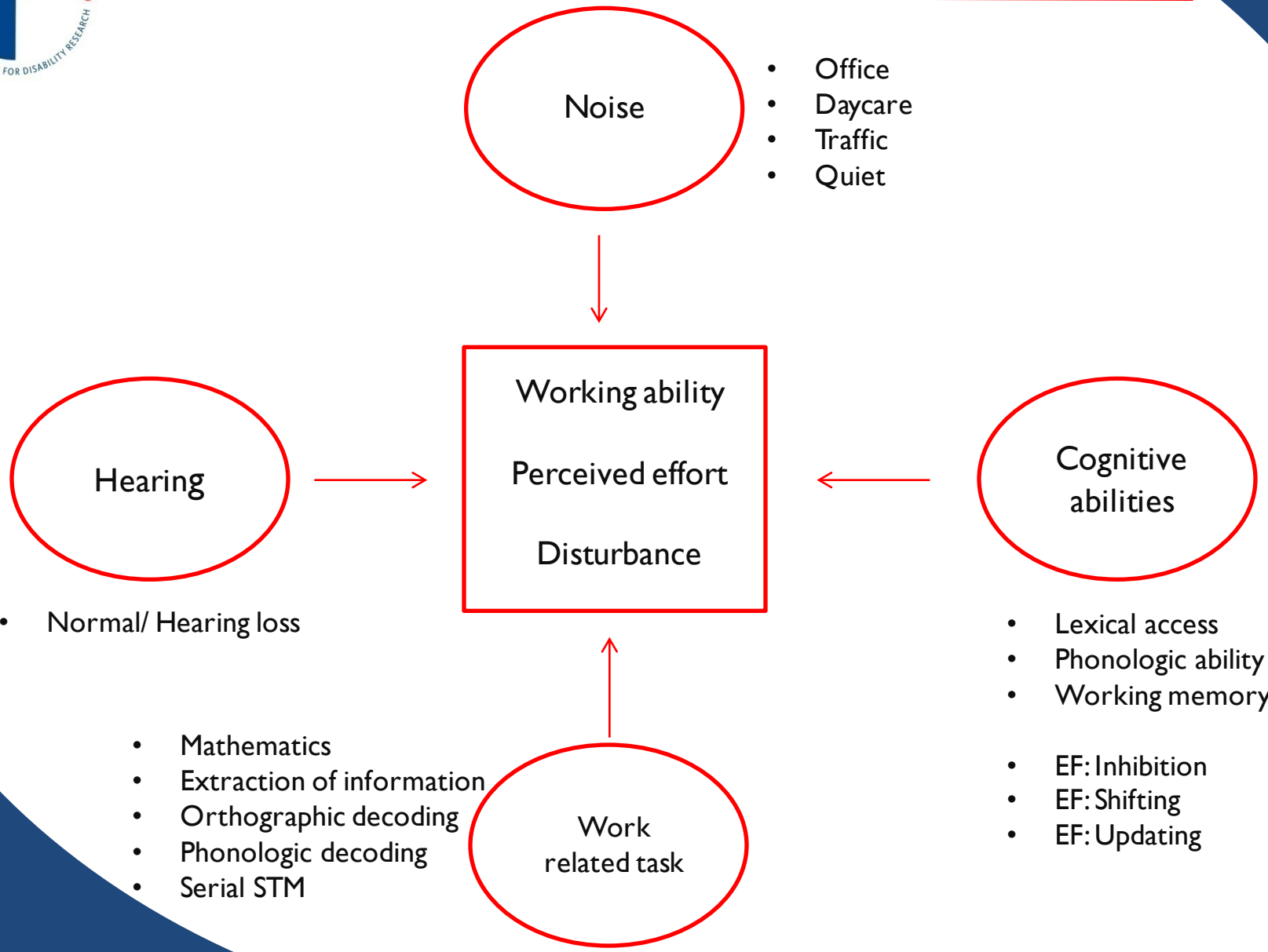
Demographics

Variable	Normally hearing	Hearing-impaired
Sex (n)		
Female	9	10
Male	11	10
Age (yrs)		
Mean	40.5	48.0
Standard deviation	14.0	12.0
Education level (n)		
Junior high school	--	1
High school	6	9
University	14	10
Work status (n)		
Student	3	1
Part-time	4	4
Full-time	13	15

Hearing

	0.5 k Hz (SD)	1 kHz (SD)	2 kHz (SD)	4 kHz (SD)	8 kHz (SD)	PTA (SD)	Speech recognition in noise (SD)
Normal hearing							
Right ear	3.8 (6.6)	4.3 (5.2)	4.0 (9.6)	9.8 (10.6)	19.0 (16.6)	5.2 (6.3)	84.1 % (6.5)
Left ear	2.3 (6.1)	2.8 (4.7)	5.8 (9.0)	13.8 (10.9)	20.3 (19.4)	7.0 (7.2)	80.7 % (4.1)
Impaired hearing							
Right ear	24.0 (16.2)	33.1 (14.1)	43.0 (12.1)	45.5 (18.1)	42.8 (24.9)	36.5 (6.0)	62.3 % (17.0)
Left ear	22.3 (15.7)	32.0 (17.8)	41.0 (12.0)	47.0 (20.7)	45.0 (25.2)	36.0 (7.0)	61.2% (16.9)

Methods


Noise
Office
Daycare
Traffic
Quiet
Working ability
Perceived effort
Disturbance
Hearing
Normal/ Hearing loss
Cognitive abilities
Lexical access
Phonologic ability
Working memory
EF: Inhibition
EF: Shifting
EF: Updating
Work related task
Mathematics
Extraction of information
Orthographic decoding
Phonologic decoding
Serial STM

Work-related tasks

- Were performed in an anechoic chamber
- Not related to any specific profession
- General working tasks that almost every profession have:
  - Math
  - Extraction of information
  - Ortographic decoding
  - Phonologic decoding
  - STM
- Two of these tasks (math and extraction of information) had two levels of difficulty

Exempel: math

- Which number is greater?
- x + y or z

- Easy:
- 5 + 6 eller 15

- Difficult:
- 484 + 289 eller 781

Extraction of information

Employee	Salary	Position	Location	Department	Recruited
Marie Svensson	34 368	warehouse manager	Skellefteå	UDA	1977
Marina Vind	11 207	caretaker	Uddevalla	ILA	1994
Bertil Wahlqvist	26 995	electrician	Skellefteå	TKA	1983
Linda Persson	39 733	warehouse manager	Uddevalla	ILA	1975
Gun Matsson	11 968	caretaker	Skellefteå	UDA	1995
Kristian Nyberg	24 828	electrician	Skellefteå	ILA	1978
Madelene Nyström	28 262	forklift driver	Uddevalla	TKA	1989
Jan-Åke Klarström	23 318	forklift driver	Uddevalla	TKA	1986
Patrik Alexandersson	26 423	forklift driver	Skellefteå	UDA	1970
Daniel Johansson	35 777	warehouse manager	Uddevalla	UDA	1966
Göran Hedvall	36 963	warehouse manager	Skellefteå	TKA	1980
Laila Adamsson	29 161	forklift driver	Uddevalla	TKA	1994
Gunilla Noresson	37 024	warehouse manager	Skellefteå	UDA	1994
Peter Erlandsson	22 486	electrician	Uddevalla	ILA	1982
Hans Falkman	34 967	warehouse manager	Skellefteå	ILA	1993

- **Easy: Who has the highest salary?**
- **Difficult: Who of those that work in Skelleftå and were employed 1993 or later has the highest salary?**

Outcome measures

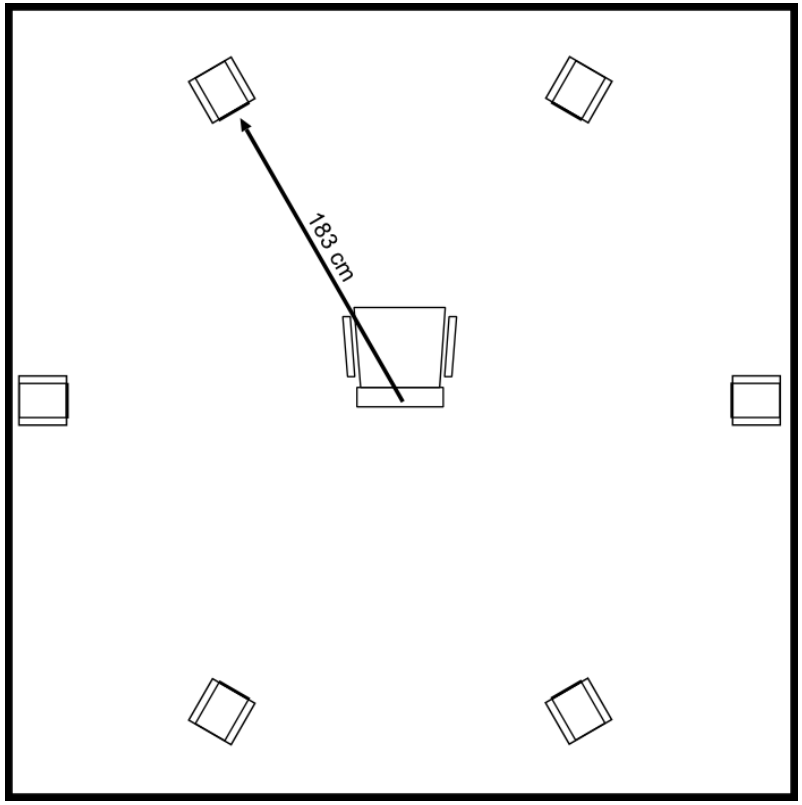
- Reaction time
- Accuracy
- Perceived disturbance (of the noise)
- Perceived effort (of the working task)

- Borg CR-10
  - Shown to be sensitive enough to detect significant differences between different types of noise

Conditions:

- Quiet
- Office noise(56.6 dBA)
- Daycare noise (73 dBA)
- Traffic noise (73 dBA)

Anechoic chamber



Anechoic chamber

Procedure

1st session

Hearing status

Cognitive tests
Lexical access
Rhyme-judgement
WMC
Inhibition
Updating
Shifting

Practice
Info. extrac
Arithmetic
Ortho. decoding
Phon. decoding
Serial recall
Borg CR-10

Break

1st condition
Info. extrac
Arithmetic
Ortho. decoding
Phon. decoding
Serial recall
Borg CR-10

Break

2nd condition
Info. extrac
Arithmetic
Ortho. decoding
Phon. decoding
Serial recall
Borg CR-10

2nd session

3rd condition
Info. extrac
Arithmetic
Ortho. decoding
Phon. decoding
Serial recall
Borg CR-10

Break

4th condition
Info. extrac
Arithmetic
Ortho. decoding
Phon. decoding
Serial recall
Borg CR-10

Questionnaires
SF-36
HHIA

Results of cognitive tests

Table 2. Mean performance and standard deviations (SDs) of the cognitive tasks for the normally hearing group and the hearing-impaired group.

Cognitive task (SD)	Normally hearing	Hearing-impaired	One-way ANOVA
Lexical decision-making	97% (0.03)	96% (0.04)	F (1, 38) = 1.1, p = 0.29
Rhyme-judgment	93% (0.05)	90% (0.12)	F (1, 38) = 1.2, p = 0.24
Reading span	60.5% (0.13)	57% (0.11)	F (1, 38) = 0.9, p = 0.40
SART errors*	2.2 (2.3)	3.1 (3.2)	F (1, 38) = -1.0, p = 0.40
The Keep track task	79% (0.13)	70% (0.15)	F (1, 38) = 2.0, p = 0.06
The number-letter task	97% (0.38)	97% (0.42)	F (1, 38) = -0.4, p = 0.70
Shifting	769 ms (320)	707 ms (444)	F (1, 38) = 0.5, p = 0.62

* total errors;

Performance of the work related task

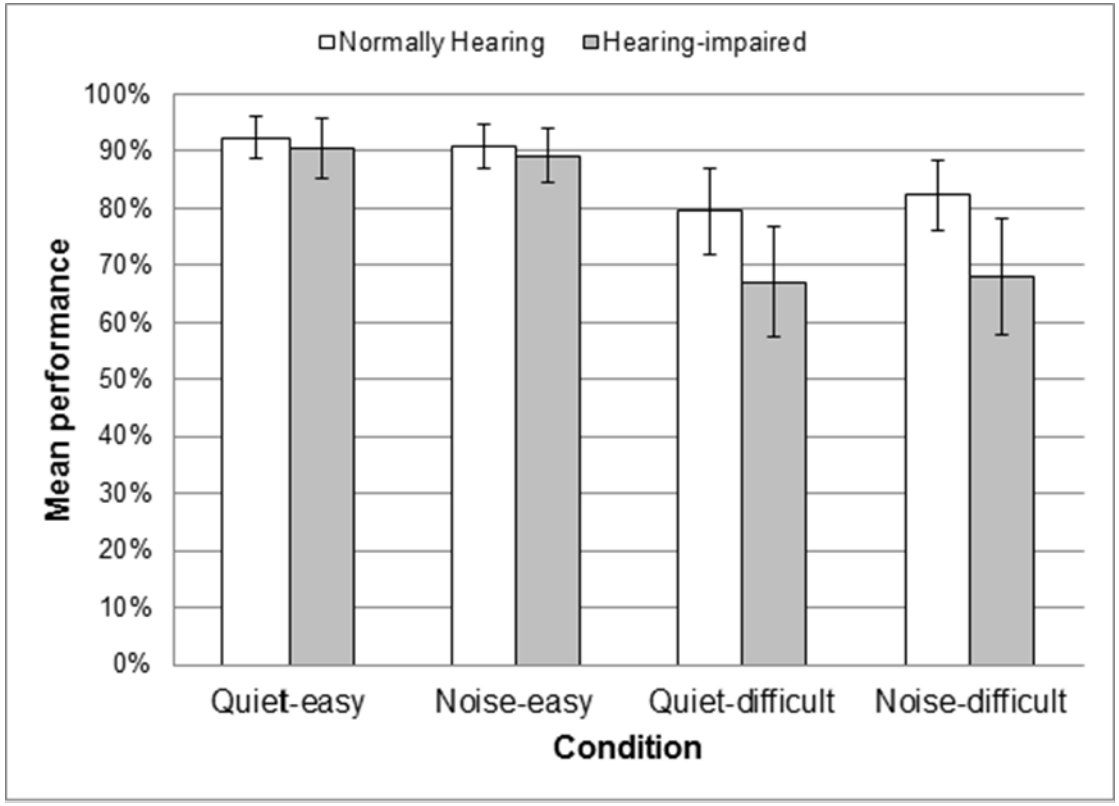


Figure 2. Mean performance in the work-related task in quiet and in traffic noise for each group (error bars denote the 95% confidence interval).

Perceived effort

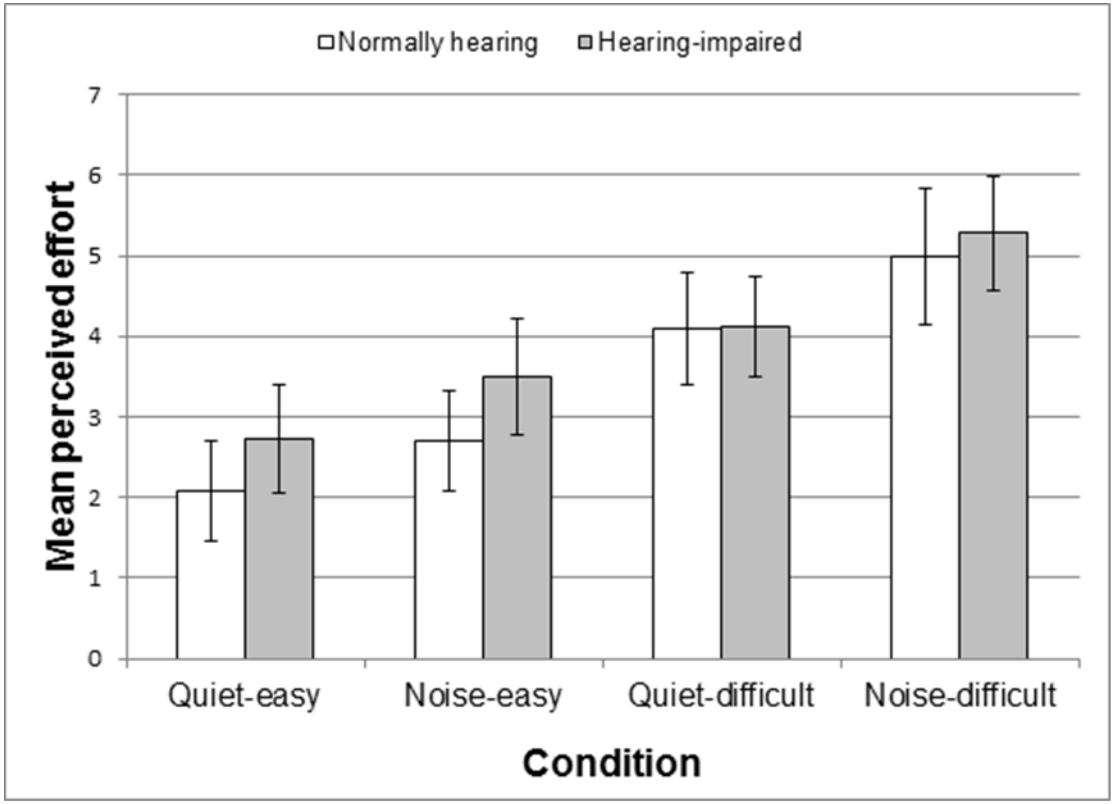


Figure 3. Means scores of perceived effort in quiet and in traffic noise for each group (error bars denote the 95% confidence interval).

Correlation between cognitive skills and PE

Table 4. Pearson correlation coefficients between cognitive skills and perceived effort in the different conditions for both groups.

	Normally hearing (n =20)				Hearing impaired (n = 20)			
	Quiet – easy	Quiet – difficult	Noise – easy	Noise – difficult	Quiet – easy	Quiet – difficult	Noise – easy	Noise – difficult
Lexical decision-making	-0.34	0.01	-0.11	-0.20	0.37	0.12	0.05	-0.07
Rhyme-judgment	-0.12	0.17	-0.27	-0.22	-0.33	-0.03	-0.36	-0.32
Reading span	-0.05	-0.22	-0.10	0.14	0.00	0.27	-0.11	0.11
SART errors	-0.39	-0.44	-0.34	-0.08	-0.06	0.11	-0.02	-0.20
The keep track task	-0.28	-0.24	**-0.55****	-0.19	-0.28	-0.14	-0.44	**-0.46***
The number-letter task	0.13	0.15	0.20	0.22	-0.14	-0.34	0.18	-0.10
Shifting	-0.16	-0.07	-0.20	-0.27	0.06	0.07	-0.07	0.03

[p = 0.02]

[p = 0.057]

Involvement of explicit processes?

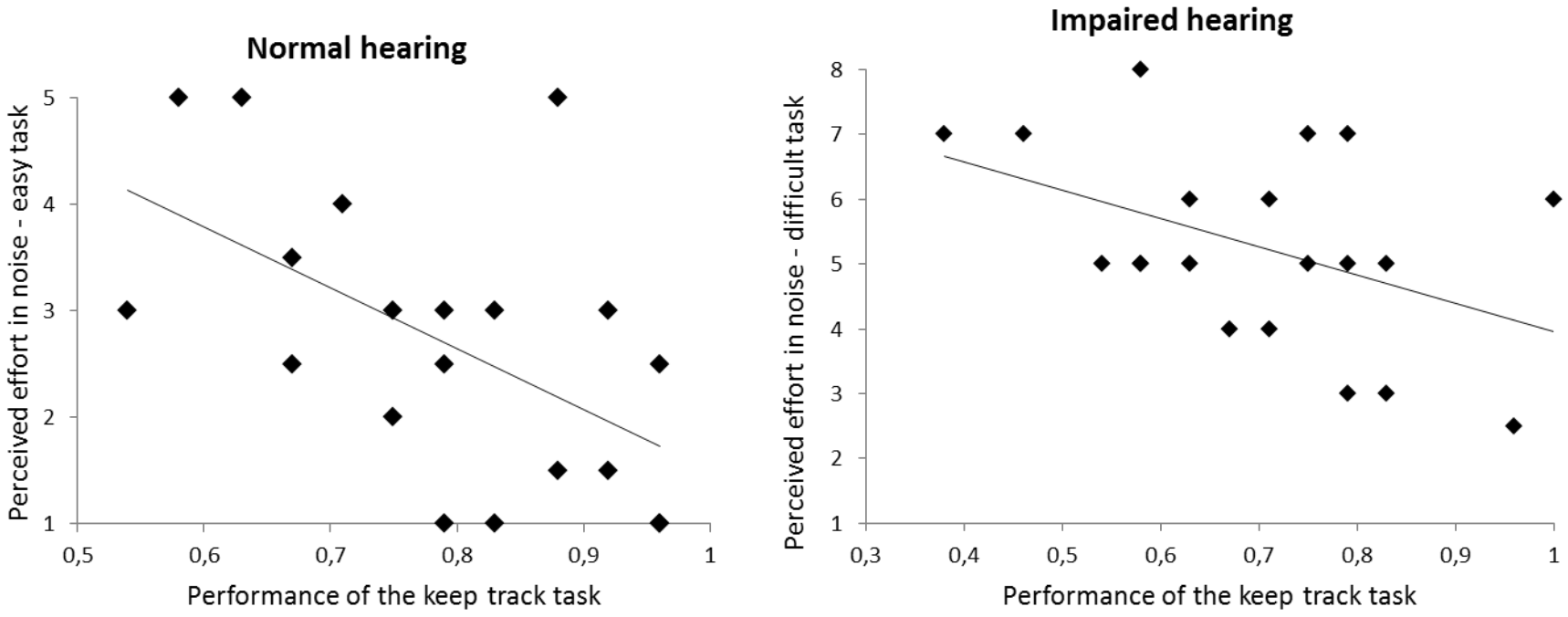


Figure 4. Scatter plots showing the significant relationship between the keep track task performance and perceived effort in noise for both groups.

Conclusions

- These findings were expected as previous studies have shown that in challenging situations, such as in noise, one has to rely more on cognitive skills (e.g. EFs).

- However, the current results also demonstrate that despite both groups went in to the experimental conditions with the same level of cognitive resources, the same working performance and rated effort; **the presence of noise seem to affect them in different ways.**

- More specifically, it affects how and when explicit processing capacity is engaged to solve the task at hand, and that a decreased performance relying on that specific process may lead to a greater PE for the individual in adverse conditions.

Results: performance of the working tasks

		Quiet	Office	Daycare	Traffic
Working task	Group	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Arithmetic task performance – easy (%)	NH	97 (4)	97 (5)	96 (5)	95 (11)
	HI	93 (22)	94 (22)	94 (22)	92 (22)
Arithmetic task performance – difficult (%)	NH	88 (10)	89 (10)	88 (7)	86 (15)
	HI	82 (25)	80 (21)	81 (23)	80 (22)
Ortographic decoding performance (%)	NH	99 (2)	98 (2)	98 (3)	98 (2)
	HI	98 (3)	99 (1)	97 (4)	99 (2)
Phonological decoding performance (%)	NH	97 (5)	98 (4)	95 (5)	97 (4)
	HI	94 (6)	93 (7)	94(8)	92 (8)
Serial recall (%)	NH	66 (14)	66 (14)	61 (18)	67 (15)
	HI	62 (19)	58 (22)	61 (18)	60 (20)
Arithmetic task RT – Easy (ms)	NH	2705 (736)	2605 (729)	2597 (757)	2582 (921)
	HI	2553 (1089)	2695(1224)	2631 (1282)	2566 (909)
Arithmetic task RT – Difficult (ms)	NH	9209 (3575)	8737 (3916)	8845 (4227)	8767 (3035)
	HI	8341 (2859)	8997 (3735)	8871 (3291)	8658 (3171)
Ortographic decoding RT (ms)	NH	1040 (244)	1044 (218)	1083 (228)	1028 (244)
	HI	1185 (336)	1215 (297)	1177 (216)	1203 (327)
Phonological decoding RT (ms)	NH	2031 (495)	2338 (553)	2401 (589)	2265(502)
	HI	2756 (761)	2751(889)	2784 (1054)	2703 (645)

Results: performance of the working tasks

Working task	F (df = 3,114)	Main effect of condition *p*-value (ηp^2)	F (df = 3,114)	Interaction effect between condition & hearing *p*-value (ηp^2)	F (df = 1,38)	Main effect of hearing *p*-value (ηp^2)
Arithmetic task performance – easy	1.1	.34 (.03)	0.3	.80 (.01)	2.4	.13 (.06)
Arithmetic task performance – difficult	0.5	.67 (.01)	0.4	.73 (.01)	0.9	.33 (.03)
Ortographic decoding performance	2.3	.08 (.06)	0.8	.51 (.02)	0.1	.93 (.00)
Phonological decoding performance	0.5	.71 (.01)	0.8	.52 (.02)	1.9	.19 (.01)
Serial recall	0.8	.50 (.02)	1.7	.17 (.01)	1.8	.18 (.03)
Arithmetic task RT – easy	0.3	.86 (.01)	0.8	.51 (.02)	0.4	.52 (.01)
Arithmetic task RT – difficult	0.3	.99 (.00)	0.6	.62 (.02)	0.1	.71 (.00)
Ortographic decoding RT	1.9	.90 (.01)	0.8	.51 (.02)	3.6	.07 (.08)
Phonological decoding RT	1.9	.14 (.05)	1.6	.19 (.04)	2.1	.17 (.04)

Results: perceived disturbance

Table 4. Mean score of perceived disturbance and standard deviation (SD) in the four background conditions for the hearing impaired and normally hearing group.

		Quiet	Office	Daycare	Traffic
Working task	Group	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Arithmetic task – easy	NH	0.7 (1.3)	2.8 (1.7)	2.9 (1.5)	3.0 (1.9)
	HI	0.3 (0.6)	2.5 (1.8)	4.2 (4.8)	4.1 (2.0)
Arithmetic task – difficult	NH	1.0 (1.9)	3.8 (1.7)	3.8 (1.8)	3.9 (2.1)
	HI	0.4 (0.8)	3.2 (1.9)	4.8 (2.3)	5.0 (2.1)
Ortographic decoding	NH	0.3 (0.8)	1.7 (1.1)	2.0 (1.1)	2.0 (1.4)
	HI	0.2 (0.5)	1.7 (1.9)	2.8 (2.5)	3.4 (2.7)
Phonological decoding	NH	0.5 (1.03)	2.3 (1.0)	2.8 (1.4)	2.9 (1.7)
	HI	0.3 (0.7)	2.2 (2.1)	3.7 (2.5)	4.0 (2.5)
Serial recall	NH	0.6 (1.0)	3.8 (1.5)	4.6 (2.3)	3.7 (2.0)
	HI	0.3 (0.8)	3.6 (2.0)	5.0 (2.6)	5.5 (2.7)

Results: perceived disturbance

Working task	F (df = 3,114)	Main effect of condition *p*-value (ηp^2)	F (df = 3,114)	Interaction effect between condition & hearing *p*-value (ηp^2)	F (df = 1,38)	Main effect of hearing *p*-value (ηp^2)
Arithmetic task – easy	37.4	.001 (.50)	4.0	.005 (.09)	0.2	.6 (.03)
Arithmetic task – difficult	38.5	.001 (.55)	3.8	.01 (.09)	0.3	.6 (.01)
Ortographic decoding	30.2	.001 (.44)	3.2	.02 (.08)	1.3	.3 (.03)
Phonological decoding	35.2	.001 (.48)	2.5	.06 (.06)	0.9	.3 (.01)
Serial recall	70.2	.001 (.65)	4.2	.007 (.10)	0.6	.4 (.02)

- **The current results demonstrate that both groups scored relatively high in accuracy and fast in RT in the different working tasks across all conditions. No significant between or within-group differences in cognitive performance of the working tasks were observed across the four background conditions**

- **Ratings of PD showed that both groups seemed to rate PD according to noise level, where higher noise level generated a higher PD. However, the present findings also indicate that the group with HI was more disturbed by higher than lower levels of noise (i.e. traffic and daycare setting compared to the office setting).**

Main findings for study 1-3

- Noise doesn't affect work performance. However…
- Noise generates a higher degree of perceived effort compared to a quiet condition for both groups and the results also indicate that explicit processing are involved to a higher degree for the group with HI when noise is present (i.e more sensitive to noise on a cognitive level)
- Higher levels of noise are also more disturbing for the group with mild-moderate aided HI
- We suggest that special consideration in hearing health care and occupational health services should be made to the individual's prerequisites on these factors in the labour market

Study 4

- The aim of paper IV was to explore the conceptions of working life among employees with mild-moderate aided HI

- Specific questions:
  - Can you describe how it feels to have a hearing impairment in the workplace?
  - How well do you think your work environment functions?
  - What impact do your hearing aids have at work?

- What factors complicates/facilitates your working tasks? Any challenges?

Method

- A phenomenographic approach was used
  - captures the variation
- 14 participants with mild-moderate aided HI was recruited + 1 pilot interview
- Transcript
- Co-judging
- Saturation of data was obtained after 10-11 interviews

Results

Table 2. Descriptive categories and description of variation within each descriptive category.

Descriptive category	Variation within descriptive category
Difficulties in daily work	Communication in groups
	Loud non-verbal noise
	Inconvenience with hearing aids
	Tinnitus
Communication strategies	Guessing/making sense of missing words using contexts
	Asking for repetition
	Move closer to speaker
	Avoid challenging listening situations
	Inform colleagues about hearing impairment
	Adjust hearing aids
	Speech reading
Facilitating factors in work environment	Support and understanding from colleagues
	Assistive listening devices
	Adjustment of room acoustics
Impact on daily life	Sense of exclusion
	Withdrawal
	Fatigue

Impact on daily life

Withdrawal:

I think it's a bit sad. Socializing after work is something I enjoy. Meeting people, hanging out and having a beer together. I don't do it very often now because of my HI. I made a conscious decision not to meet up because I find communicating difficult. I used to talk a lot with people, even those I didn't know, but I don't anymore (No.11).

Sense of exclusion:

What's most difficult is when someone makes a joke during class and everyone laughs except me. Or when I ask someone to repeat what they said for the third time and I still cannot hear because there is too much noise. It's embarrassing. I often believe that people might think I'm stupid, but I know I'm not (No. 6).

Facilitating factors in work environment

Acoustical adjustments:

"They put new insulation on the ceiling that is very absorbent. They also put down a large mat that absorbs quite a lot of noise. I feel that there's a huge difference between working in my classroom and going into somebody else's classroom that has not been sound proofed. I think the pupils think so too. There is a big difference between being in a facilitating environment and an aggravating one (No. 4)."

Assistive listening devices:

If I have my **Bluetooth device** I can sit like this in my office and talk on the phone. There's really no need for me to do anything else because the sound goes straight into my ears and I wear the microphone around my neck. It's also easier for me to hear [during seminars] when there's an audio system in the hall. I think people with good hearing think so too. (No. 3)."

Conclusions/clinical implications

- Similar findings reported by Hétu et al (1998) and Hallberg & Carlsson (1991). Findings are also in agreement with our quantitative results.

- Even though a majority of the participants perceived HA as something useful and helpful, many of them could still perceive it as a complicating factor in certain situations (outside work, moise/sweat, hearing protectors, protective glasses, etc.)

- Need for extensive services in audiologic rehab for this group?
  - Need of assistive listening devices?
  - Communication strategies
  - Information to colleagues and employers about the consequences of having a HI
  - Acoustical adjustments?

- Younger women and daycare personnel? Young adults?

Acknowledgment

Project members:

Björn Lyxell

Claes Möller

Stephen Widén

Research audiologists:

Jennie Hjaldahl

Kristina Ingvall

Arvid Björndal

Research engineers:

Tobias Åslund

Jonas Birkelöf

Co-authors:

Jan Karlsson

Magnus Emilsson

Rachel Ellis

Kim Kähäri

Agneta Anderzén

afa FÖRSÄKRING

Colleagues:

Elisabeth Classon

Gitte Keidser

Sushmit Mishra

Elaine Ng

Jerker Rönnberg

Adriana Zekveld

Thank you!

INSTITUTET FÖR HANDIKAPPVETENSKAP
LINNÉCENTRUM HEAD FORSKARSKOLA