**Supplementary material**

Supplementary table 1 Comparison of participating and non-participating sample

Supplementary tables 2ab Sensitivity analyses: prevalence rates of auditory hallucinations in the past four weeks

Supplementary table 3 Sensitivity analyses: Multivariate regression models on the effect on hallucinations for each category of hearing impairment severity

Supplementary tables 4abc Sensitivity analyses including participants aged 65 or over only

Supplementary questionnaire 1a 14-item semi-structured interview, used for hallucination assessment

Supplementary questionnaire 1b Background information for conduction of hallucination interview

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| **Supplementary table 1. Basic demographic characteristics and comparison of participating and non-participating sample.** | | | | | | |
|  |  | **Participation**  (n = 1,007) | **No participation**  (n = 840) | **p** a | **Z** | **df** |
| **Age** | In years; median (range) | 57 (18 – 92) | 55 (18 – 93) | .60 | - .52 | **-** |
|  |  |  |  | **p** b | **χ 2** | **df** |
| **Gender** | Female; no.(%) | 477 (47.4) | 444 (52.9) | .019 | 5.5 | 1 |
| **Hearing** | Hearing impairment present; no. (%) | 854 (84.8) | 663/809 c (82.0) | .10 | 2.7 | 1 |
| a Mann-Whitney U test, 2-tailed p-value  b Pearson Chi-square, 2-tailed p-value  c Data to calculate presence of hearing impairment missing in 31 non-participants, excluded from comparison.  dpt., department; ENT, ear-nose-throat; df, degrees of freedom; no., number | | | | | | |

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| Supplementary table 2ab. Sensitivity analyses: prevalence rates of auditory hallucinations in the past four weeks.  Additional results from uni- and multivariate analyses upon request. | | | | | | | |
| Supplementary table 2a. Prevalence of hallucinations after omission of participants (n=65) with a history of hallucinations from the non-hallucinating group. | | | | | | | |
| Prevalence | **Subcategory** | **n** | **Hallucination prevalence**  (past four weeks) | | **Statistics** a | | |
|  |  |  | **n** with hall | **%** | **χ 2** | **p** | **df** |
| Total | Total | 942 | 144 | 15.4 | - | - | - |
| …stratified for presence of impairment | No impairment | 167 | 10 | 6.0 | 13.6 | <.001 | 1 |
| With impairment | 775 | 134 | 17.3 |
| …stratified for severity of impairment | No impairment | 167 | 10 | 6.0 | 26.4 | <.001 | 5 |
| Unilateral impairment | 241 | 31 | 12.9 |
| Mild impairment | 201 | 28 | 15.4 |
| Moderate impairment | 182 | 33 | 18.1 |
| Severe impairment | 86 | 22 | 25.6 |
| Profound impairment | 65 | 18 | 26.2 |
| Supplementary table 2b. Prevalence of hallucinations after omission of participants (n=141) with pure tone audiometry on other day than hallucination interview. | | | | | | | |
| Prevalence | **Subcategory** | **n** | **Hallucination prevalence**  (past four weeks) | | **Statistics**  a | | | |
|  |  |  | **n** with hall | **%** | **χ 2** | **p** | **df** |
| Total | Total | 861 | 119 | 13.8 | - | - | - |
| …stratified for presence of impairment | No impairment | 171 | 10 | 5.8 | 11.4 | .001 | 1 |
| With impairment | 690 | 109 | 15.8 |
| …stratified for severity of impairment | No impairment | 171 | 10 | 5.8 | 23.0 | <.001 | 5 |
| Unilateral impairment | 235 | 26 | 11.1 |
| Mild impairment | 185 | 26 | 14.1 |
| Moderate impairment | 145 | 29 | 20.0 |
| Severe impairment | 71 | 16 | 22.5 |
| Profound impairment | 54 | 12 | 22.2 |
| a Pearson Chi-square, 2-tailed p-value  Categorisation of severity of impairment: None: High Fletcher Index (HFI) both ears 0-<25 dB. Unilateral: HFI best ear 0 - <25 dB, HFI worst ear 25-125 dB. Mild: HFI best ear 25-<40 dB. Moderate: HFI best ear 40-<60 dB. Severe: HFI best ear 60-<80 dB. Very severe: HFI best ear 80-125 dB. | | | | | | | |

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| Supplementary table 3. Sensitivity analyses: results of five separate multivariate logistic regression analyses a. | | | | | | | | | | | | | |
| **Degree of impairment** a | **Total n=…**b | **Statistics**  Effect on outcome (hallucinations) | | | | | **Other variables in the model**  Effect, indicated with OR (95% CI) | | | | **Model fit** | | |
|  |  | **OR** c | **95% CI** | **β** | **SE** | **p** | **Tinnitus** | **Age** | **Sex** | **Impairment L>R** | **R2C** | **R2N** | **H&L** |
| None (reference group) | 173 | - | - | - | - | - | - | **-** | - | - | - | - | - |
| Unilateral | 433 | 2.6 | 1.2 - 5.5 | .94 | .39 | .015 | 0.9  (0.4-1.9) | **0.98**  **(0.95-0.99)** | 2.0  (0.98-3.9) | 0.8  (0.4-1.5) | .034 | .072 | .92 |
| Mild | 387 | 3.8 | 1.6 - 9.0 | 1.3 | .43 | .002 | 1.1  (0.5-2.4) | 0.98  (0.96-1.01) | 1.9  (0.96-3.7) | 1.1  (0.5-2.1) | .035 | .071 | .22 |
| Moderate | 363 | 5.4 | 2.1 - 13.7 | 1.7 | .48 | <.001 | 1.3  (0.6-2.8) | 0.99  (0.96-1.01) | 1.2  (0.6-2.4) | 0.7  (0.3-1.3) | .044 | .086 | .68 |
| Severe | 268 | 7.0 | 2.5 - 20.4 | 2.0 | .54 | <.001 | 1.5  (0.6-3.9) | 0.99  (0.96-1.02) | **2.5**  **(1.1-5.8)** | 0.8  (0.3-1.7) | .086 | .17 | .49 |
| Profound | 243 | 5.4 | 2.0 - 14.4 | 1.7 | .50 | .001 | 1.5  (0.6-3.7) | 1.00  (0.98-1.03) | 1.6  (0.7-3.7) | 1.2  (0.5-2.9) | .070 | .14 | .28 |
| a: Each row represents a separate multivariate regression model, which calculates the effect of a specific degree of impairment on the outcome (auditory hallucinations), in comparison to a group of participants without hearing impairment. Each of these models is applied to a subpopulation featuring the indicated impaired group and the reference group without impairment (n=173).  b: The group with no impairment (n=173) serves as the reference group in every analysis. Categorisation of impairment severity conform figure 1.  c: Total number of participants included in the subanalysis (n[subpopulation] = n[reference group] + n[indicated impaired group]).  d: Indicates the odds ratio of having current auditory hallucinations in the indicated severity group, in comparison to the group without impairment.  OR, odds ratio; 95% CI, 95% confidence interval; SE, standard error; R2C, R2 of Cox & Snell; R2N, R2 of Nagelkerke; H&L, Holmes & Lemeshow level of significance. | | | | | | | | | | | | | |

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| Supplementary table 4a. Prevalence of hallucinations (n=312). | | | | | | | |
| Prevalence | **Subcategory** | **n** | **Hallucination prevalence**  (past four weeks) | | **Statistics** a | | |
|  |  |  | **n** with hall | **%** | **χ 2** | **p** | **df** |
| Total | Total | 312 | 47 | 15.1 | - | - | - |
| …stratified for presence of impairment | No impairment | 9 | 0 | 0.0 | 1.64 | .200 | 1 |
| With impairment | 303 | 47 | 15.5 |
| …stratified for severity of impairment | No impairment | 9 | 0 | 0.0 | 21.6 | .001 | 5 |
| Unilateral impairment | 43 | 2 | 4.3 |
| Mild impairment | 78 | 9 | 11.5 |
| Moderate impairment | 98 | 12 | 12.2 |
| Severe impairment | 55 | 13 | 23.6 |
| Profound impairment | 29 | 11 | 37.9 |
| a Pearson Chi-square, 2-tailed p-value  Categorisation of severity of impairment: None: High Fletcher Index (HFI) both ears 0-<25 dB. Unilateral: HFI best ear 0 - <25 dB, HFI worst ear 25-125 dB. Mild: HFI best ear 25-<40 dB. Moderate: HFI best ear 40-<60 dB. Severe: HFI best ear 60-<80 dB. Very severe: HFI best ear 80-125 dB. | | | | | | | |

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| Supplementary tables 4abc. Sensitivity analyses including participants aged 65 or over only (n=312). |

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| Supplementary table 4b.Univariate comparison of potentially associated factors in hallucinations in the past four weeks (n=312) | | | | | | | |
|  |  | **Hallucinations**  (n = 47) | **No hallucinations**  (265) | **Odds Ratio**  (95% CI) | **χ 2** | **p** a | **df** |
| **Sex** | Female; no.(%) | 18 (38.3) | 108 (40.8) | 0.9 (0.5 - 1.7) | .10 | .75 | 1 |
| **Tinnitus** | Ever present; no.(%) | 39 (83.0) | 186 (70.2) | 2.1 (0.9 - 4.6) | 3.2 | .072 | 1 |
|  | Present in past four weeks; no.(%) | 37 (78.7) | 172 (64.9) | 2.0 (0.95 - 4.2) | 3.4 | .063 | 1 |
| **Hearing lateralization** | Impairment more severe in left ear; no.(%) | 27 (57.4) | 138 (52.1) | 1.2 (0.7 - 2.3) | .46 | .50 | 1 |
|  |  |  |  |  | **Z** | **p** b |  |
| **Hearing impairment severity** | Severity of impairment in the best ear; HFI, in dB; median (IQR) | 61.7 (41.7 – 78.3) | 43.3 (30.0 - 60.0) | - | -4.2 | <.001 | - |
| **Age** | In years; median (IQR) | 71 (68 - 74) | 70 (67 – 75.5) | - | - .11 | .91 | - |
| a Pearson Chi-square, 2-tailed p-value. b Mann-Whitney U test, 2-tailed p-value  95% CI, 95% confidence interval; df, degrees of freedom; no., number; IQR, Interquartile range; HFI, high fletcher index; dB, decibel | | | | | | | |

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| Supplementary table 4c. Potentially associated factors in hallucinations in the past four weeks; multivariate logistic regression analysis (n=312) a*,* b. | | | | | | | |
|  |  | **OR (95% CI)** | **β** | ***SE* β** | **Wald’s 2** | **df** | **p** |
| **Sex** | Female | 0.9 (0.4 - 1.7) | -.17 | .34 | .23 | 1 | .63 |
| **Tinnitus** | Present in past four weeks | 2.0 (0.9 - 4.4) | .71 | .39 | 3.2 | 1 | .073 |
| **Hearing** | Impairment more severe in left ear | 1.2 (0.6 - 2.3) | .18 | .33 | .28 | 1 | .60 |
|  | Severity of impairment in the best ear (HFI, in dB) | 1.03 (1.02 - 1.05) | .031 | .007 | 18.6 | 1 | <.001 |
| **Age** | In years | 0.96 (0.91 - 1.03) | -.036 | .031 | 1.3 | 1 | .25 |
| a Constant variable: β -1.3, SE β 2.3, Wald 2 .35, df 1, p .55, exp(β) 0.3.  bNagelkerke’s R2 .126, Cox & Snell R2 .072, Hosmer and Lemeshow goodness of fit .97  OR, odds ratio; 95% CI, 95% confidence interval; SE, standard error; df, degrees of freedom; HFI, high fletcher index; dB, decibel; 95% CI, 95% confidence interval | | | | | | |  |

# Supplementary questionnaire 1a. 14-item semi-structured interview, used for hallucination assessment.

English translation. Dutch version (original) upon request.

**Screening form “Spontaneous Acoustic Phenomena”**

Age: Date of screening:

Gender: Location:

Research number: Interviewer:

**ENT information**

Left ear Right ear

Otological diagnosis:

High Fletcher Index:

Hearing aid:

**Short introduction:** “Sir/madam, people with hearing illnesses are mostly bothered by the fact that they hear less than people with good hearing. Yet, they can sometimes hear things that other people cannot. These sounds can be humming, or squeaking, and can even consist of music, or spoken language. It is about those sounds that I wish to ask you some questions, within the context of scientific research. The questions will take about 10 minutes. Participation is voluntary. If you prefer not to participate, it will not have negative consequences for your treatment. May I ask you the questions?”

**QUESTIONNAIRE**

1. Have you ever heard sounds different from normal? Yes - No

(e.g. with an echo, booming, or with a strange pitch?)

1. Do you experience tinnitus, peeping, or buzzing? Yes - No

If so, did you experience that during the past 4 weeks? Yes - No

Can you describe the sound?

1. Have you ever heard something wrong, i.e. that you thought you Yes - No  
   heard something, but it turned out to be something else?

If so, did you experience that during the past 4 weeks? Yes - No

Can you give an example?

1. Have you heard sounds no-one else could hear? Yes - No

5. Have you heard song or other sorts of music, while nothing or Yes - No

nobody was making/playing that music?

1. Have you heard voices speak while nobody was with you? Yes - No
2. Have you heard sounds, voices, or music that arose from inside Yes - No  
   your head?

8. Have you experienced other special things related to hearing? Yes – No  
If so, can you describe your experience?

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**9. Is patient a possible case? Yes - No**

If no: end the interview. If yes: continue questionnaire.

1. Can you describe what you have heard?

Are those sounds complex auditory phenomena? Yes - No

1. Did these sounds appear as real as actual sounds? Yes – No  
   (or more like hearing in thoughts)

1. Could it have been a different sound that you heard wrong? Yes - No
2. When did you hear the sounds for the last time? \_\_\_\_\_\_\_\_\_

(for the interviewer)

1. **Are there complex auditory phenomena? Yes - No**

**Supplementary questionnaire 1b. Background information for interviewer using supplementary questionnaire 1a.**

Standardized additional information regarding screening form “Spontaneous acoustic phenomena”; can be used as a reference for trained interviewers. English translation, Dutch version upon request.

**Question 1:** this question regards *unformed* hallucinations. This is a phenomenon often pathognomic for certain diseases of hearing (e.g. hyperacusis). Complex auditory hallucinations are formed by definition.

**Question 2:** this question regards tinnitus. Tinnitus can be regarded as a *formed, non-complex* hallucination. Its cause has not yet been unravelled. Tinnitus can occur in both hallucinating and non-hallucinating patients. It is interesting to unravel the prevalence of tinnitus in the hallucinating group, in comparison to the prevalence of tinnitus in the entire study sample.

**Question 3:** this question regards the occurrence of illusions. In this way, one can distinguish a hallucination from an illusion.

**Question 4-8:** these questions closely resemble each other. They all have a slightly different angle to them, thereby enlarging the chance of potential cases bringing their hallucinations up than if only one of these questions would have been asked. Also, these questions distinguish between musical and verbal hallucinations.

**Question 9:** if question 1 until 8 have all been answered with ‘no’, the participant is considered to not have hallucinations. In that case, the interview is over. If a participant answers question 1 until 8 with ‘yes’ one or more times, or in case the participant or researcher has any doubt, the researcher can decide to continue the interview with question 10.

**Question 10:** be as complete as possible. There is a grey area between simple and complex hallucinations. Cases of doubt will always be reviewed in a later phase of the study. Therefore, it is important that anyone is able to reproduce the description given by the participant at any given time, and in full detail.

**Question 11:** this question regards the occurrence of mental imagery. Examples of mental imagery are so-called musical ‘ear worms’, a symptom that occurs frequently in mood disorders such as OCD, or depression. In this way, one is able to distinguish between the occurrence of hallucinations and mental imagery.

**Question 12:** this question regards the occurrence of illusions. In this way, one is able to distinguish between the occurrence of hallucinations and illusions.

**Question 13:** this question provides insight in the current presence of events.

**Question 14:** based on the information from the previous questions, the researcher is now able to judge whether or not spontaneous, complex hallucinations are present. A complex hallucination is a hallucination on which the participant bestows a certain amount of meaning; e.g.: participant continuously hears a gurgling stream of water. Ask in such cases: “do you hear sounds that only resemble a gurgling stream of water (…) ” (most likely tinnitus/non-complex), “(…), or do you actually hear a gurgling stream of water?” (most likely complex).