Aku20 - Searching for Optimal Single Number Quantities in EN ISO 717-2 Correlating Field Measurements 20-5000 Hz to Occupant's Ratings of Impact Sounds – New findings for concrete floors

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Summary

Two versions of a question on impact sounds from neighbouring spaces in dwellings have been demonstrated to return different results. At first, a new version of a questionnaire appeared to be imprecise, too broad etcetera and therefore it returned higher annoyance ratings than the previous, more specific question. But the previous version may have been too restricted – disturbing sounds other than footstep sounds in building with concrete floors seem be a greater problem than anticipated. If so, concrete floors may have appeared to perform better in the previous surveys than occupants actually experience. A modified questionnaire is used in a current survey, which asks for specific sources of impact sounds.

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1. Introduction

Swedish building regulations set limits on the standardized impact sound pressure levels in dwellings, schools, offices and hospitals. These limits refer to EN ISO 717-2, where both $L'_{nT,w}$ and $L'_{nT,w} + C_{I,50\text{-}2500}$ must be less than 56 dB in dwellings. Many developers request a higher sound class where these levels must be lower than 52 dB.

Sweden may be the only country using the spectrum adaptation term with the extended frequency range 50-2500 Hz in its building regulations, which came into force in 1998. This decision was actually supported by all relevant parties, also the manufacturers of light weight building elements whose products by then performed unfavourable compared to heavier products (in particular with respect to their sound insulations at low frequencies). But the industry supported the change and started a development process. Today, up til eight storey multifamily houses are raised in several cities using various types of prefabricated timber frame system which fulfill the new requirements and sometimes even the stricter limits mentioned above.

However, the number of unsatisfied occupants in these wood framed buildings remains higher than expected, and research is ongoing to find out possible reasons[1]. Results from the previous AkuLite research project have been presented in a paper[2]. At the inter-noise congress in 2013[3], one main finding was described:

"Considering the impact sound, both $L'_{n,w}$ and $L'_{n,w}+C_{I,50\text{-}2500}$ indicated poor correlation to subjective perception of impact sound. When frequencies down to 20 Hz was included, a significant improvement was achieved using $L'_{n,w}+C_{I,\mathbf{20}\text{-}2500}$. The highest correlation was obtained by a modified C_I-term with even more emphasis to the lowest frequencies, $L'_{n,w}+C_{I,AkuLite,\mathbf{20}\text{-}2500}$."

This interpretation of the AkuLite results were based on comparisons between field measurements and questionnaire studies, mainly in timber or steel frame buildings, but listening tests in the laboratory supported the conclusions. The new term $L'_{n,w}+C_{I,AkuLite,\mathbf{20}\text{-}2500}$ is recommended in the fourth edition of the Swedish sound classification standard SS 25267:2015.

Previous surveys incorporated buildings with floors made of heavy and stiff concrete which performed well,

they all had a low degree of subjective annoyance from walking sounds.

However, new results presented below, indicate that the results for concrete floors may have been biased by the question in the AkuLite-questionnaire and occupants in buildings with concrete floors might in fact be less satisfied with impact sounds in general than indicated by previous studies. This is discussed below.

2. COST TU 0901 questionnaires

Within the research action COST TU 0901[4], various templates for a harmonized questionnaire was discussed and outlined to fit to the needs of various countries participating. Its question #5 on impact sound from the neighbours used in the AkuLite project came from an early version[3], see Figure 1. Later in the action, this early version was considered somewhat problematic and the working group agreed on new questions with a broader scope, see Figure 2. It was not analyzed at this time what these changes could impose on the interpretation of a question, because the AkuLite-style of direct questions would hinder the researchers to get permissions to perform studies which would be fatal. So there were strong reasons to find a compromise upon the end of the COST action. Further information on the development of the questionnaire templates is presented in the e-books[5].

3. Survey results in 5 concrete buildings

The new version, according to Figure 2, was tested in a survey of 5 buildings with floors made of 25 cm massive concrete, cast in situ, with a 14-15 mm parquet floor floating on a 3 mm underlay for reduction of tensile loads and impact sound transmission (ΔL_w 17 dB according to EN ISO 717-2). These buildings comprised 80-120 households each and were selected to include a variety of conditions that may influence the outcome. The buildings include rental and owned apartments, they are located in newly populated areas or old parts of a city, they were either occupied by young families with children or mainly by senior persons.

The ratings given by the occupants in self owned apartments by question 5 was highly surprising: About 40% rated the annoyance 3 or higher, 20% rated 5 or higher, 5% rated 8 or higher. In the rented apartments, the ratings were even worse: About 45-55% rated the annoyance 3 or higher, 30-40% rated 5 or higher, 15-25% rated 8 or higher.

The measurements agreed well with the impact sound level numbers expected for this common type of construction, $L'_{nT,w}$ and $L'_{nT,w} + C_{I,50\text{-}2500}$ 49-51 dB which fulfills the building regulations and also the higher sound class B of SS 25267. $L'_{n,w}$-values were about 2 dB higher.

Then, the difference between the new questionnaire and the old (AkuLite) was discussed. Could the broader scope have caused an unforeseen effect? Could noise from the floors in the same apartment (drum sounds) and noise from other activities than walking influence the results?

4. Complementary survey

For the purpose of comparing the two versions of questionnaire, a small extra-survey was conducted. 50 occupants were selected from three of the areas included in the major study, who had rated the annoyance 3 or higher. These occupants were only asked to give their answers to three questions (to help the researcher sort out a problem with the previous survey):

1. Neighbours; footstep noise, i.e. you hear when they walk on the floor
2. Impact noise; e.g. people walking, dragging furniture, dropping toys etc (comment___)
3. Sounds from your own floor when you or somebody else walks on it, e.g. thuds, squeeks

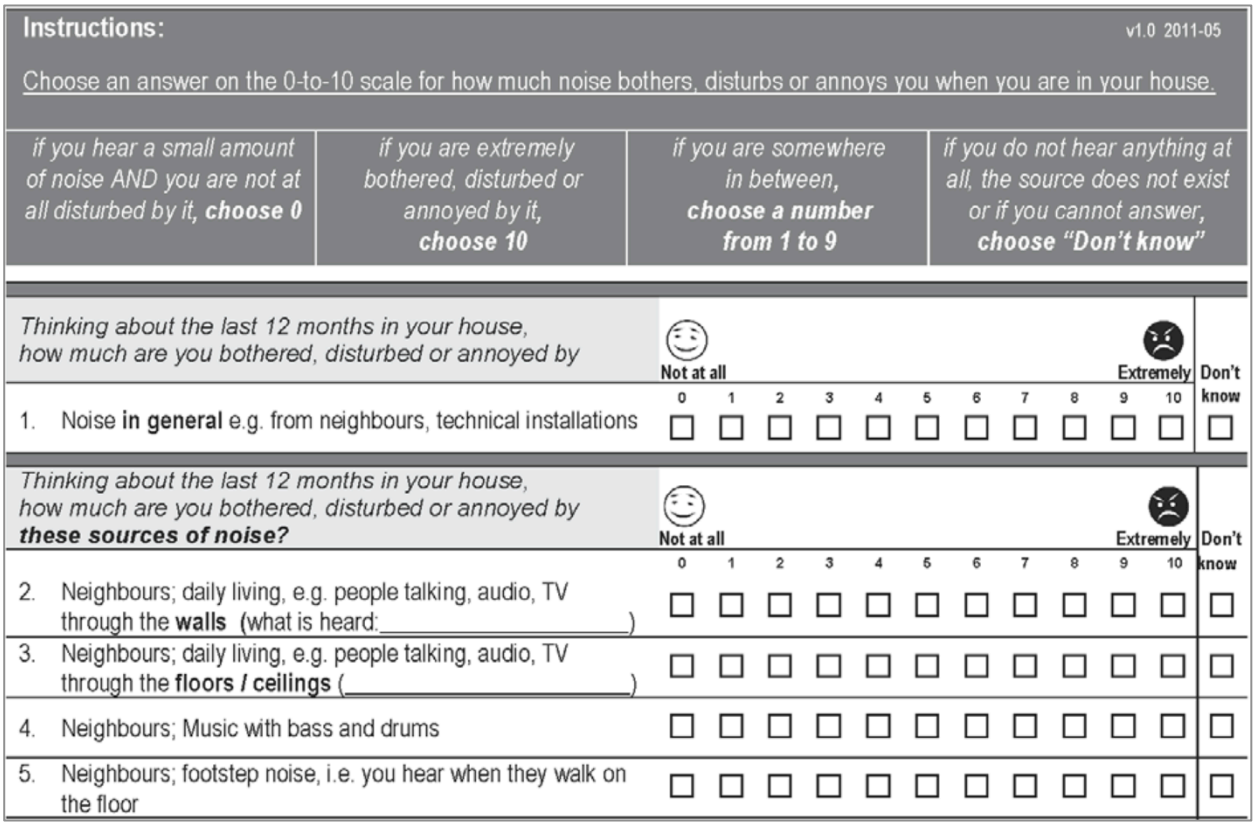
27 occupants of the 50 responded (54% response rate, no reminders sent), which is acceptable. In order to facilitate analyses of the results, the average ratings and their 95% confidence intervals were calculated:

1. Average 4,3 with its CI-95% +/-1,3
2. Average 6,5 with its CI-95% +/-1,3
3. Average 1,7 with its CI-95% +/-1,1

The average responses are apparently higher than in the original survey, which is natural since the respondents were selected only from the fraction being annoyed.

The results indicate the new question 5 with the broader scope (COST) tends to return 1.5 times higher annoyance ratings compared to the older (AkuLite) version. Sounds from the own floor did not return ratings that are likely to explain the difference found. Furthermore, all free text comments were analyzed, and they actually described a variety of impact sounds that were considered somewhat disturbing, e.g. toys dropped or furniture moved on the floor above.

The first reaction was that the new question is imprecise, too broad etcetera. But a different interpretation is also possible – that the previous question was too restricted – disturbing sounds other than footstep sounds in building with concrete floors seem to have been "hidden" in previous surveys.



Instructions: v1.0 2011-05

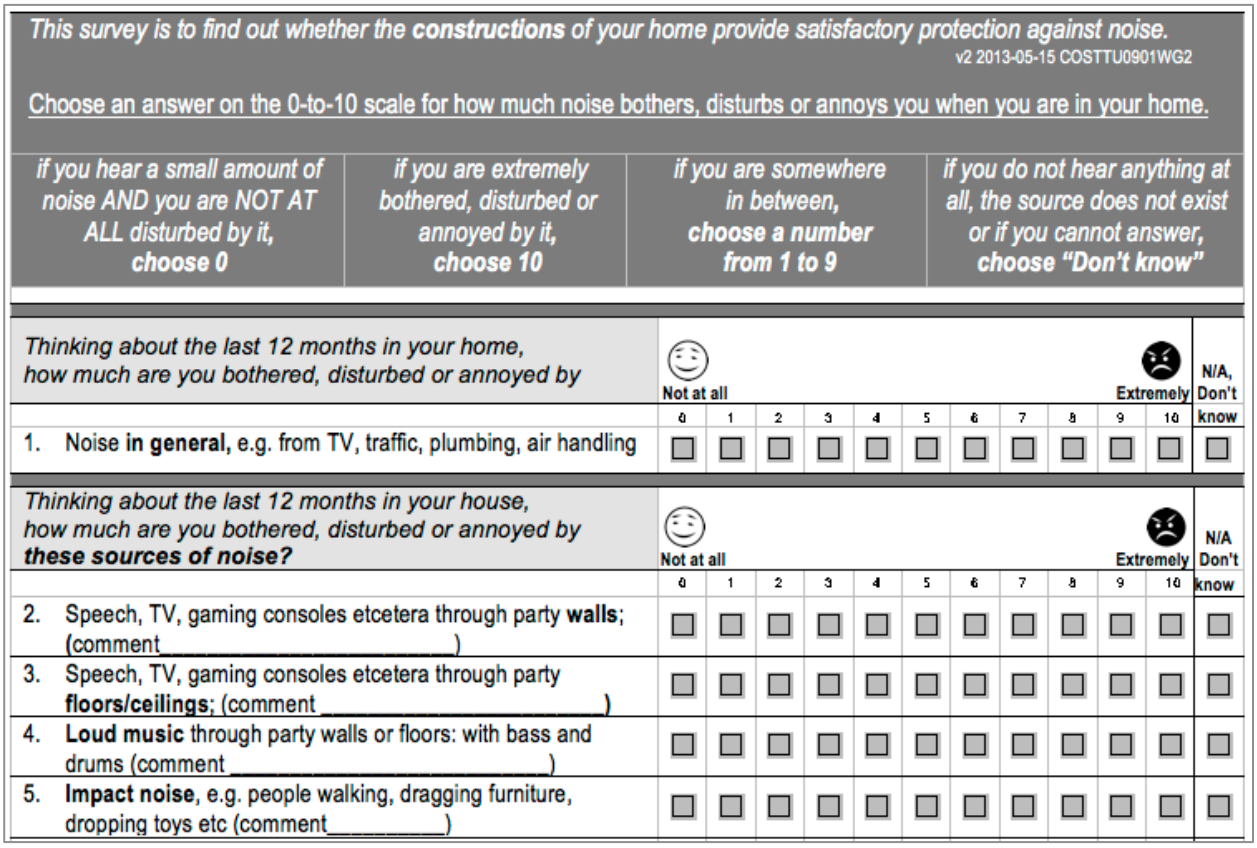
Choose an answer on the 0-to-10 scale for how much noise bothers, disturbs or annoys you when you are in your house.

if you hear a small amount of noise AND you are not at all disturbed by it, ***choose 0***	*if you are extremely bothered, disturbed or annoyed by it,* ***choose 10***	*if you are somewhere in between,* ***choose a number from 1 to 9***	*if you do not hear anything at all, the source does not exist or if you cannot answer,* ***choose "Don't know"***

Thinking about the last 12 months in your house, how much are you bothered, disturbed or annoyed by	Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely	Don't know
1. Noise **in general** e.g. from neighbours, technical installations	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐

Thinking about the last 12 months in your house, how much are you bothered, disturbed or annoyed by ***these sources of noise?***	Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely	Don't know
2. Neighbours; daily living, e.g. people talking, audio, TV through the **walls** (what is heard:_____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
3. Neighbours; daily living, e.g. people talking, audio, TV through the **floors / ceilings** (_____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
4. Neighbours; Music with bass and drums	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
5. Neighbours; footstep noise, i.e. you hear when they walk on the floor	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐

Figure 1. AkuLite version (early COST action) of the questionnaire, used for socio-acoustic surveys in 10 buildings.



This survey is to find out whether the ***constructions*** *of your home provide satisfactory protection against noise.*

v2 2013-05-15 COSTTU0901WG2

Choose an answer on the 0-to-10 scale for how much noise bothers, disturbs or annoys you when you are in your home.

if you hear a small amount of noise AND you are NOT AT ALL disturbed by it, ***choose 0***	*if you are extremely bothered, disturbed or annoyed by it,* ***choose 10***	*if you are somewhere in between,* ***choose a number from 1 to 9***	*if you do not hear anything at all, the source does not exist or if you cannot answer,* ***choose "Don't know"***

Thinking about the last 12 months in your home, how much are you bothered, disturbed or annoyed by	Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely	N/A, Don't know
1. Noise **in general,** e.g. from TV, traffic, plumbing, air handling	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐

Thinking about the last 12 months in your house, how much are you bothered, disturbed or annoyed by ***these sources of noise?***	Not at all 0 1 2 3 4 5 6 7 8 9 10 Extremely	N/A Don't know
2. Speech, TV, gaming consoles etcetera through party **walls**; (comment_____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
3. Speech, TV, gaming consoles etcetera through party **floors/ceilings**; (comment _____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
4. **Loud music** through party walls or floors: with bass and drums (comment _____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐
5. **Impact noise**, e.g. people walking, dragging furniture, dropping toys etc (comment_____)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐

Figure 2. Final COST TU 0901 version of the questionnaire, used for socio-acoustic surveys in 5 buildings.

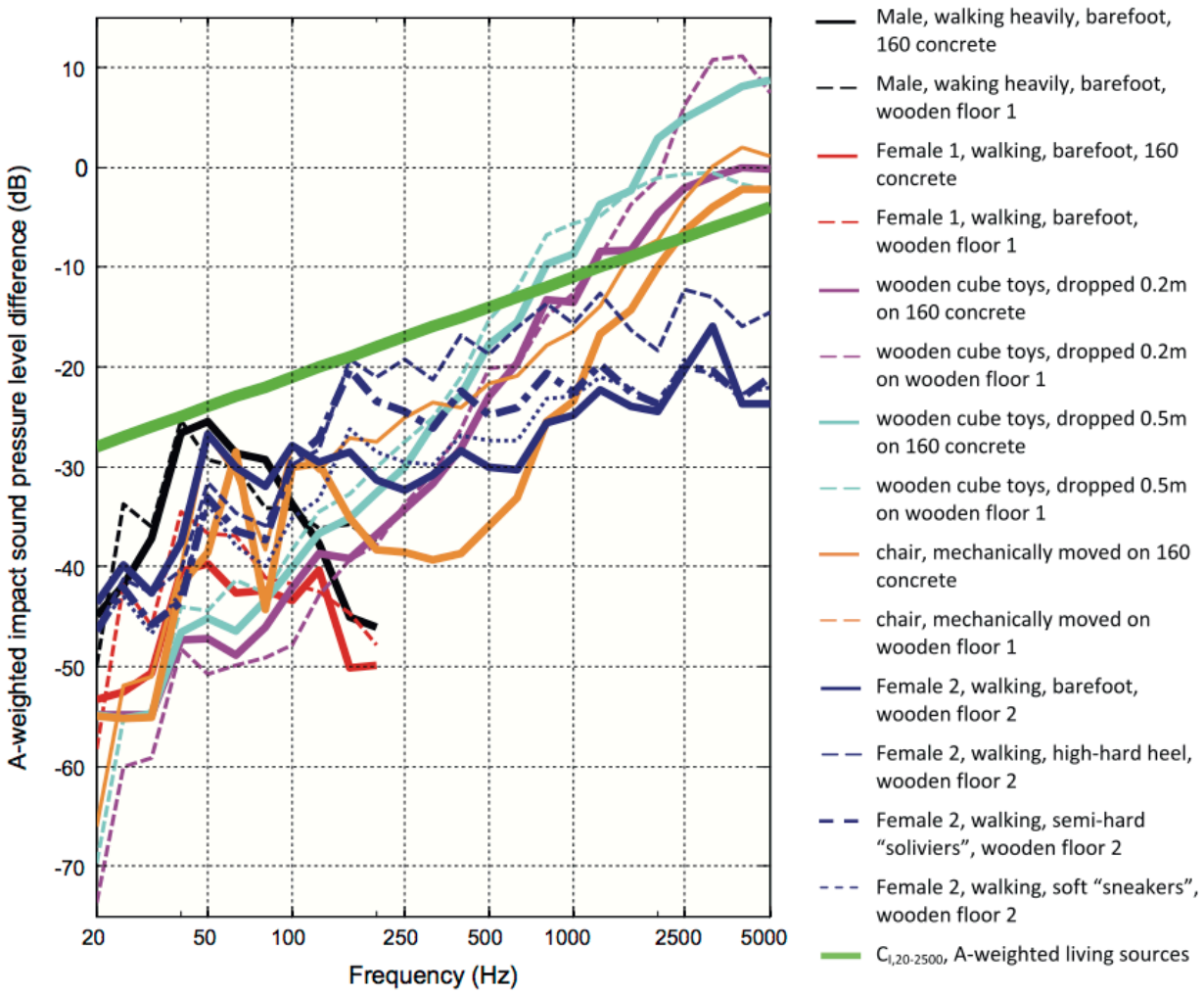


Figure 3. A-weighted differences between normalized impact sound pressure levels measured with various impact sources and the levels obtained with the tapping machine. (Figure 9 in the paper[2]).

A possible reason for annoyance from sounds from toys, chairs etcetera is that the parquet floor has a limited impact sound reduction at frequencies above the resonance frequency (about 400 Hz). As demonstrated in the paper[2], such hard impact sources impose substantial energy at high frequencies compared to walking barefoot or walking in soft rubber sole shoes as is common in our country. This is illustrated in Figure 3 below, taken from the paper[2]. Thus, the two kinds of impact sources should preferably be treated separately in a revised questionnaire.

5. Current research – Aku20

In the ongoing research project Aku20[1], the AkuLite version is still used, but a special question has been added, that specifically addresses other impact sounds, e.g. from chairs, kitchen, cupboards, toys, vacuum cleaning etcetera. Also, a new question has been added on how satisfied the respondent is with the dwelling, in general.

The purpose is to enable analyses of whether general satisfaction (or its opposite) may explain systematic bias of ratings of the noise conditions.

The measurement scheme has also been changed, such that more time is devoted to measurements with both the standardized tapping machine and the soft impact source in ISO 10140, i.e. the japanese rubber ball.

6. Conclusions

Two versions of questions on impact sounds from neighbouring spaces in dwellings have been demonstrated to return different results. At first, a new version of a questionnaire seemed to be too imprecise, too broad etcetera and therefore returned higher annoyance ratings than the older, more specific question.

But a different interpretation is also possible – the previous question may have been too restricted – disturbing sounds other than footstep sounds in building with concrete floors seem be a greater problem

than anticipated. If so, concrete floors may have appeared to perform better in the previous surveys than occupants actually experience, once the question includes other types of impacts than from footsteps.

Comments (free field texts) indicate that childrens play, toys dropped, furniture moved, kitchen work, furniture dragged, vacuum cleaning etcetera do constitute sources of noise in buildings with concrete floors.

It remains to see how light weight floors perform with respect to hard impacts from toys etcetera.

References

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