Sound design strategies in composing pleasant and unpleasant acoustic environments inside a living room in a European residential context

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SOUND DESIGN STRATEGIES IN COMPOSING PLEASANT AND UNPLEASANT ACOUSTIC ENVIRONMENTS INSIDE A LIVING ROOM IN A EUROPEAN RESIDENTIAL CONTEXT

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ABSTRACT

Acoustic comfort arouses interest in sociology, psychology and building industry since the sixties. It can be defined in first approach as the absence of unwanted sounds and the presence of adapted sounds while doing an activity. Comfort is influenced by the acoustic performances of building, by the various types of sound sources, and by individual attitudes (sociological background, musical preferences etc.). In this study, the impact of sound sources on the pleasantness of typical domestic ambiances is investigated using a "sound design" approach when a composition of sounds is listened coming from three distinct spatialized channels (from outside, from inside the room and from the neighbour). Via a computer interface, 65 people had to adjust the level of each of the three channels on the composition while keeping the overall equivalent level constant at 40 dB(A) in order to design optimized sound scenes. The compositions of the most pleasant sound environments were obtained in reducing SPLs of the neighbour sounds in most situations (TV. documentary, children, work, and party). Two sound masking strategies were revealed. One group preferred to increase the ventilation noise level in the room by 2.5 dB(A), the other group increased sound levels from outside by 3 dB(A). Alternative strategies are found for the two types of musical sounds coming from the neighbour. For classical music, most participants increased in average its sound level by 3 dB(A). Regarding popular music, sound preferences lead to 3 sound strategies. People who like popular music increased the sound level of this sound source by 3 dB(A) in average. One group mixed it with the ventilation in the room, the other with sounds from the outside of the building. People who dislike the pop music stimulus reduced its sound level by 4.5 dB(A) in average and increased the sound level of the sources coming from the outside.

1. CONTEXT

In order to better understand the acoustic comfort in a context of living room in residential area, a series of three perceptual experiments was carried out in a controlled laboratory context (see § 2.4). The main objective of this study was to assess the sound insulation performance effects of the building elements on the comfort perceived by inhabitants. So a perceptual experiment was carried out, focusing on the impact of successive acoustic renovations of a simulated building from the 1920's to 2020. Sound perception is driven by acoustic and non acoustic factors, so in this study, the hypothesis is that confort does not only depend on building sound insulation, but also on personal factors such as sensitivity, type of music preferences, etc. People were then invited to participate to this study (see § 2.1) with a careful corpus selection. In order to better understand their preferences towards the different sound sources that are present in a living room, two pre-tests were carried out with always the same participants. This research follows an original psycho-cognitive approach. While a psycho-acoustic method has been chosen for the two pre-tests, asking for attentive and focused listening to participants, a cognitive approach has been preferred for the final experiment asking people for achieving different tasks, subjecting them to interior sound ambiance (passive listening) of a living room as close as possible to real life conditions (ecological validity). The first pre-test was dedicated to the assessment of the pleasantness of individual sound sources coming from outside (traffic noise, birds, citizens, etc.) or from inside the building (neighbours or ventilation) [1]. This first pre-test showed that more sensitive persons rated all stimuli less pleasant than non sensitive persons. It showed also that popular music was appreciated by some participants, even coming from their neighbour, whereas others hated it. The second pre-test was dedicated to the combination of the previous individual sounds. Indeed, in a dwelling, many sound sources can be simultaneously heard, accounting for the superposition of various sound sources coming from the adjacent neighbour, from the outside of the building, and from the interior of the accommodation itself. The aim of the second pre-test was to study the different strategies that could be chosen by people if they had the possibility to mask some sounds by other sources in a living room, keeping constant the global sound level. Sound masking effects might lead to changes in pleasantness evaluations. These masking strategies were evaluated via an interactive interface through which the participants adjusted the relative sound level between the sources in order to obtain an optimized sound environment (see § 2.5). Two successive optimizations were requested, the first aiming at obtaining the most pleasant sound environment and the second, the most unpleasant. This sound design approach was inspired by Brocolini's study [2] accounting for possible optimizations when means of controlling the sound environment are given to individuals. This second pre-test is detailed in this paper.

2. METHOD AND MATERIAL

2.1 Participants

66 listeners participated in the listening test. A hearing test was conducted for every participant and the audiogram release showed that 1 listener had too significant hearing losses in order to remain in the corpus, based on the audiometric classification of hearing impairment [3]. Among the 65 remaining participants (42 % male / 58% female), 54% were workers aged 30 to 50 and 46% were students aged 18 to 30. All participants grew up in urban or outlying suburbs and they lived in a residential building at the time of the listening test. Median of the noise sensitivity distribution is about 6.5 over 10 based on a sensitivity questionnaire [4]. Participants were given gratification for their duties.

2.2 Selection of sound sources

Semantic categories of urban sound environments have been studied and defined in the literature [5–8]. Categorization of environmental sound sources including domestic stimuli have also been studied [9,10] distinguishing categories according to their types. Based on a literature review, 35 sound sources have been selected for a first listening pre-test [1]. 65 individuals rated the pleasantness of every stimulus. All stimuli had been chosen and composed to be the prototypes of their semantic categories. Based on the results of the first pre-test, a selection of sound sources has been carried out according to three criteria. On the one hand, the musical preferences highlighted in the first pretest should be evaluated in the second. Thus, popular music stimuli have been kept. Then, more consensual sounds have been chosen to cover a wide spectrum of pleasantness rated from the most unpleasant (work at the neighbour, road traffic from the outside), to the most pleasant (sounds of nature, classical music). Finally, rather unpleasant sounds have been chosen to complete the selection with coming from the neighbour: 1) Children voices, and 2) TV documentary ; and coming from the outside through the facade: 1) Nature and human voices, 2) Human voices and road traffic, and 3) Aircraft flyover. In total, 30 combinations of sound sources have been optimized consisting in crossing 6 neighbouring sound sources with 5 sound sources coming from the outside of the building. The interior ventilation was always part of the combinations.

Background noise in the room was about 23 dB(A). Stimuli were composed in selecting samples from sound libraries (BBC sound library, Free Sound, Urban Sound, Universal sound bank, and Free sound) or thanks to direct measurements carried out using either Zoom H7 recorder (with XY mics) or ORTF CCM Schoeps microphones. In both cases, a combination of Left+Right channels was performed to get mono signals. These mono signals are then auralized following a method described in section 2.4.

2.3 Building acoustic performances

When an acoustic wave encounters a building component, the propagation through the materials filters the incoming signal. Even if for this pre-test, the influence of the building was not studied, the filtering induced by the simulated performances of the building components should be taken into account. The simulated building consisted in a 4 mm simple glazing facade of (1.45 x 1.40) m^2 and a 12 mm thick concrete wall. The partition with the neighbour consists in an alveolar partition 72. In order to account for the geometry of the simulated building and the performances of its constituent materials, Statistical Energy Analysis (SEA) calculation was performed. The simulations took into account the different transmission paths of the sound waves through the building components. The simulation results are presented in Table 1. The building performance is low so that each of the sources could be more easily interpreted and understood. Based on the simulations, the sound insulation curves DnT were estimated. They defined the FIR (Finite Impulse Response) filters (for each third octave band) which were applied to the sound signals according to the origin of sound (Facade FIR filter for the sound sources coming from the outside, and Neighbour FIR filter for the sound sources coming from the room next door).

Building separation	**Rating denomination**	**Acoustic performance [dB]**
Neighbour	$D_{nT,w}$	**31**
	$(C; C_{tr})$	(-1 ; -2)
	$(C_{50-3150}; C_{tr,50-3150})$	(-1 ; -2)
Facade	$D_{2m,nT,w}$	**32**
	$(C; C_{tr})$	(-1 ; -2)
	$(C_{50-3150}; C_{tr,50-3150})$	(-1 ; -2)

Table 1: Estimation of airborne sound insulation between rooms (the neighbour) and against outdoor sounds calculated based on ISO 12354/1-2017, and ISO 12354/3-2017 standards [11,12]. Correction coefficients are calculated in accordance with standard ISO 717/1-2013 [13].

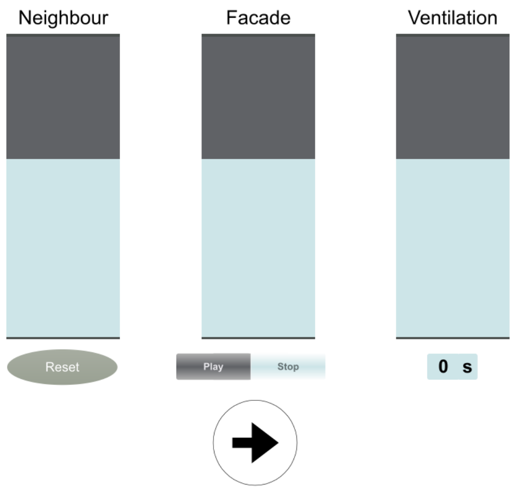
2.4 The laboratory

The laboratory and its sound reproduction system have been presented at CFA'18 [14]. The sound reproduction system consists in 16 Yamaha HS7-I speakers and 1 Genelec 7070A subwoofer driven by 1 audio processor Yamaha DME64N. Sound strategies are designed and controlled through the software Max/MSP 7. Auralization strategy for this second pre-test consisted in placing 9 regularly spaced virtual point sources for each radiating surfaces of the room (the facade, and the adjacent neighbour's partition). Every point source was then spatially rendered using Vector Based Amplitude Panning (VBAP) [15].

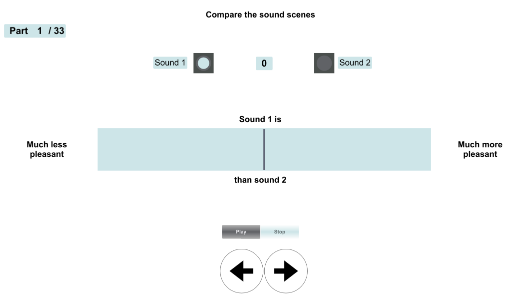
Figure 1: Picture of the spatialized sound reproduction laboratory (La MIR, Neuville sur Oise, France)

2.5 Method

The interface of the test is presented in Figure 2 and takes place in 3 steps for each combination of sources. It is controlled by a tablet for the entire duration of the experiment. Three sound tracks are presented. Each of them plays in loop a 30-second sound stimulus of an equivalent level $L_{Aeq,30s}$ equal to 35.25 dB(A) so that the overall level consisting of the sum of the three scenes is equal to 40 dB(A). The first track corresponds to the sound stimulus coming from the adjacent neighbour located to the right of the participant, the second corresponds to the source coming from the glass facade in front of the participant coming from outside the building and finally the third corresponds to a ventilation inside the room. First of all, the participant had to adjust the sound level of each track in order to obtain the most pleasant sound environment possible (see Figure 2a). Since the program is designed so that the equivalent sound level $L_{Aeq,30s}$ remains constant equal to 40 dB (A), if the participant increases a sound track by 1 dB (A) then the level of the other two is decreased by 0.6 dB so that the equivalent sound level remains constant. Each track can have a maximum sound level equal to 38.75 dB (A) which corresponds to an increase of 3.5 dB (A) compared to the initial situation. In order to ensure a constant equivalent sound level in dB (A), the program adjusts the level of the other two tracks according to the Equation 1. Let L_1, L_2, et L_3 be the sound levels of the tracks of the neighbour, the facade, and the ventilation respectively. Assuming a participant adjusts the gain by a value x ($x \in [-5, 3.5]\, dB(A)$) for one of the tracks and for example the track 1 of the neighbour. So, to get the value y to add to the levels L_2, and L_3, the program applies the following formula:



(a) GUI - First two steps: Create (1) the most pleasant sound environment, and (2) The least pleasant sound environment.



(b) GUI - Third step: Comparison of the two created sound environments on a pleasantness semantic scale.

Figure 2: General User Interface (GUI) description.

$$y = -10\log_{10}\left[1 + \frac{10^{\frac{L_1}{10}} - 10^{\frac{(L_1+x)}{10}}}{10^{\frac{L_2}{10}} + 10^{\frac{L_3}{10}}}\right] \qquad (1)$$

With:

- $L_2 := L_2 + y$;
- $L_3 := L_3 + y$.

Once the participant was satisfied with her/his most pleasant mix, he/she proceeded to the second step. The second step is the exact opposite of the first stage. The participant had to obtain the least pleasant sound environment. Once the second sound environment has been composed, the participant then continued towards the third stage presented in Figure 2b. At this stage, the participant had to listen to the two sound compositions he just mixed individually. Then, he was asked to compare them and assess if sound 1 is more or less pleasant than sound 2. The participant answered on a semantic scale of 101 points ranging from -50 (much less pleasant) to +50 (much more pleasant). To avoid the fact that the preferred stimulus would be always on the same side of the slide, the most pleasant environment and the least one were reversed for 50% of the evaluations. This three-step cycle ends by pressing the "Validate" button. As long as this button was not pressed, the participant could go back up to the first step in order to compare the situations and make some changes if needed. Once he pressed the "Validate" button, the choice was irreversible and the participant would then go to a new combination of sources.

3. RESULTS

In order to highlight the strategies chosen by the participants, one Principal Component Analysis (PCA) is carried

out per subset of data. For each of the 30 evaluated combinations over the entire test, 6 gain ratings are recorded for every participant, corresponding to the results for the three origin of sounds (Neighbour, Facade, and Interior ventilation) coupled with the two successive instructions (most pleasant, and least pleasant). For each PCA corresponding to one neighbour sound source, the objects are the other sound sources coming from the outside plus the ventilation one, and the variables are the participants. So, the dimensions correspond to specific strategies shared by correlated participants.
Regarding four of the six neighbour sources studied, the same trends are found out. The results for these sources are therefore presented together in the following section. These are the non musical neighbour sound sources of indoor work, television documentary, children, and party.

3.1 Non musical neighbour sound sources

3.1.1 Principal optimization strategies

Since for the 4 non-musical neighbour sources the same trends are observed, only one diagram is presented illustrating the results where the neighbouring source consists in drilling work. The results of the PCA is presented in Figure 3. Two dimensions are needed. A description of

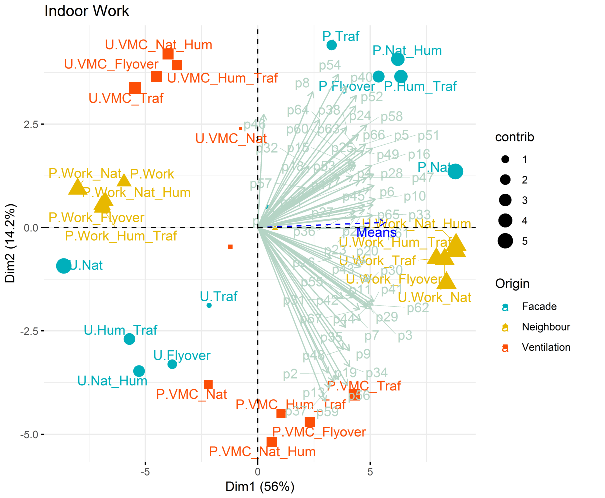


Figure 3: Correlation diagram from the PCA carried out on the subset of data where the sound source "Drilling work" from the neighbour is involved.

the nomenclature is proposed. Every arrow corresponds to the correlation of each individual profile to the two main dimensions of the PCA. The individual profile consists in all of personal rating responses during the first two steps of the procedure presented in Figure 2. Each marker corresponds to the contribution of each sound source to both PCA dimensions depending on its origin (Neighbour, Facade, Interior) and for every mix in which the noise of the source "Drill work" is involved. When the observation corresponds to a result in the case of the "most pleasant" instruction, the observation label begins with "P" for Pleasant, and when the instruction is "the least pleasant", the observation label begins with "U" for Unpleasant.
PCA shows that a consensus is found since all participants are highly and positively correlated to the first dimension. This first dimension is characterized by the gain applied to the neighbour's track. The participants are therefore unanimous in increasing the noise level of the "Indoor work" source in order to obtain the most unpleasant sound environment and to reduce its noise level to compose the most pleasant environment. This is visible on the diagram because the participants correlations to dimension 1 are positive, and the coordinates of the contributions of the neighbour's gains are also all positive in the unpleasant cases, and all negative in the pleasant cases. For all facade sources (with the exception of nature sounds), there are two specific strategies highlighted by the second dimension of the PCA. The participants positively correlated with this second dimension choose to increase the gain of the facade sources to compose the most pleasant environment. In contrast, participants negatively correlated with this same dimension prefer to mask the unpleasant source of indoor work by increasing the sound volume of the interior source of ventilation. This behaviour trend is also observed for the three other sound environments including the non-musical sound sources: wildlife documentary broadcast sample, the children's voices samples and the party noise sample. However for these four neighbouring sources, the source of nature from the facade contributes only a little to the second dimension of the PCA and on the other hand contributes a lot to the first dimension. This indicates that when the sounds of nature are involved in the combinations, the two masking strategies highlighted by the PCA are no longer relevant. To study the source of nature sounds, one specific analysis is preferred and will be presented in Section 3.2. Beforehand, the strategies highlighted for the 4 cases of non-musical neighbour sources must be quantified in terms of mean equivalent levels per origin of source.

3.1.2 Mean quantification L_{Aeq}

Figure 4 presents the 2 highlighted sound combinations chosen by the participants when the sounds of indoor work are involved. The same trends are also observed for the other 3 non-musical neighbouring sound sources. The mean results and standard deviations presented in Figure 4 are calculated per subgroup of participants revealed by the previous PCA. The individual proportion having chosen either of the strategies is also represented thanks to the variable size of the markers.
We observe that in the case of the subgroup "1 3 2", the equivalent level $L_{Aeq,30s}$ of the neighbour's source is always around 30 dB(A), that of Facade about 38 dB(A) (result fairly close to the maximum possible of 38.75 dB(A)) and finally that of ventilation about 33 dB(A). With a difference of 8 dB(A) between the equivalent levels of facade and of the neighbour, the neighbour sound source is no longer perceived. The sound environment is then made up of a combination of ventilation and the soundscape coming from the glass facade.

The alternative strategy "1 2 3" aims to use the interior ventilation to mask the others by increasing its level by almost 2.5 dB(A) in average (Order "1 2 3" in Figure 4).

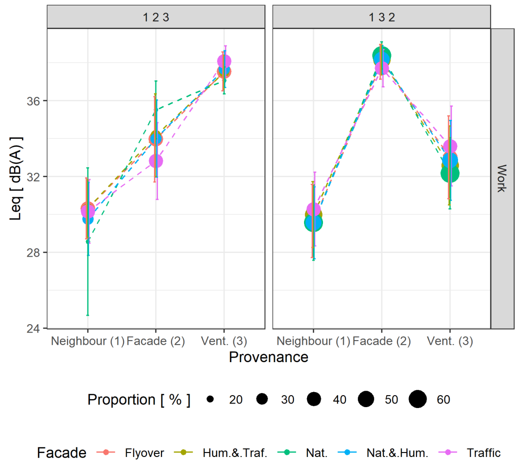


Figure 4: Most pleasant optimizations when the indoor work from the neigbour are involved. Mean results and standard deviations for the equivalent sound levels according to the two main points of view. The two dominant strategies are named "1 2 3" and "1 3 2" in reference to the increasing order of the sound levels according to the origin of sound. The size of the markers represents the proportion of participants who chose either of the 2 strategies.

3.2 Specific situation for one facade source: The sounds of nature

3.2.1 Optimization strategies

For this source, a PCA is performed on the subset of all the results in which the sounds of nature are involved. The correlation diagram synthesizing the results is presented in Figure 5. Two dimensions are needed and only the participant P34 is not well represented on the diagram. To compose the "most pleasant" environment, the level of nature sounds is always increased. Then, two combination strategies are found out. The first aims to mix the ventilation sounds with the sounds of nature. The other option reveals a combination of nature sounds and the intrusive sounds from the neighbour. These two strategies are highlighted by the analysis of the dimension 2. Thanks to this second dimension, we observe the division between the participants who increase the gain of the music from the neighbour (classic, or popular music) and who mix it with the sounds of nature and those who on the contrary prefer to lower it to obtain the most pleasant environment. These two musical stimuli will be studied in the the Section 3.3. Before that, a representation of the average combinations is presented in the specific situations where the sounds of nature coming from the facade are involved.

3.2.2 Mean quantification L_{Aeq}

This stimulus composed with sounds of nature is one of the few having been appreciated by all the participants during the evaluation of pleasantness of the first listening test and presented at the ICA'19 [1]. Figure 6 presents the results for the two dominant strategies when the sounds of nature are involved. One of the strategies consists in increasing the sounds of nature by almost 2.5 dB (A) and to lower the neighbour's sounds by following the increasing order of levels "1 3 2". The participants who followed this strategy preferred to mix the sounds of nature with the indoor sounds of ventilation in the accommodation. This strategy is the most shared within the participants. However, another strategy is found out following the order $L_{Aeq.vent} < L_{Aeq.neighbour} < L_{Aeq.facade}$. In this case, the sounds of nature are mixed with the sounds from the neighbour. This strategy is more often chosen when the sounds of nature are mixed with the sounds of classical or popular music from the neighbour. Two sources coming from the neighbour haven't been mixed following the same way than the four already presented in Section 3.1. These two sound sources have in common to be musical,

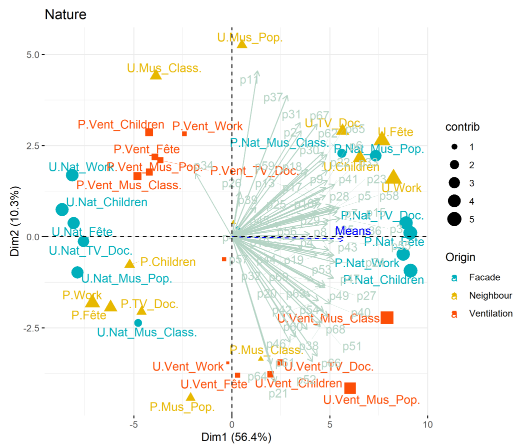


Figure 5: Correlation diagram from the PCA carried out for the subset for which sounds of nature are involved.

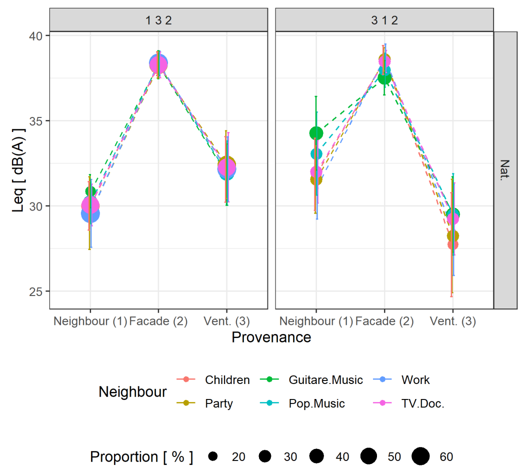


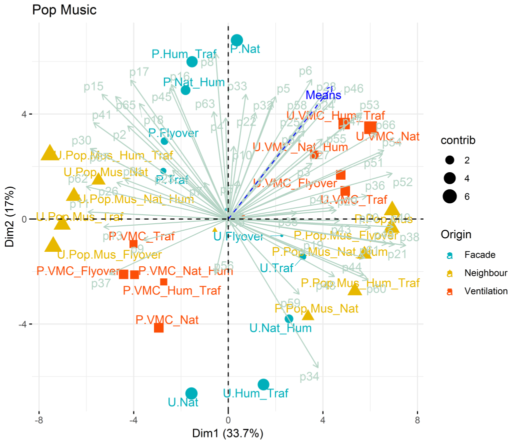
Figure 6: Most pleasant optimizations when the sounds of nature from outside are involved. Mean results and standard deviations for the equivalent sound levels according to the two main points of view.

but the music styles are different: one being popular, the other being classical.

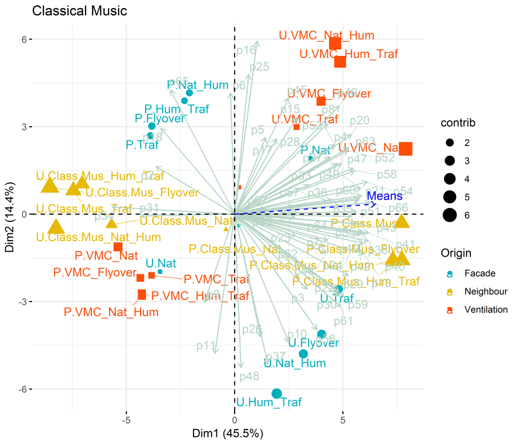
3.3 Popular and classical music coming from the neighbours

3.3.1 Principal optimization strategies

Pop. music: The diagram in Figure 7a highlights the 3 main strategies. Indeed, the dimension 1 does not correspond to a consensus between participants, and reveals two different strategies. One group increases the noise level of the neighbour's source to compose the most pleasant scenario. On the contrary in the least pleasant case, it decreases it. This group positively correlated to the first dimension is divided into two subgroups, some of them are positively correlated with the second dimension, and the others negatively. Some participants decided to mix the popular music with the facade source, deceasing the ventilation, others prefer to mix this kind of music with the ventilation sound, decreasing the facade source. This interpretation is carried out by analysing the dimension 2 of the PCA presented in Figure 7a. Finally, a last group consisting of participants negatively correlated with the first dimension tends to decrease the level of the source of pop. music and to increase the sounds coming from outside in order to compose the most pleasant sound environment.
Classical music: Figure 7b shows that 90% of the panel decided to increase the neighbour's sound volume to create the most pleasant sound environment. The ventilation / facade source divide is once again observed with half of the participants preferring to mix classical music with the ventilation source and the other half with the facade source in order to compose the most pleasant sound environment.



(a) Pop. music Ed Sheeran



(b) Classical music

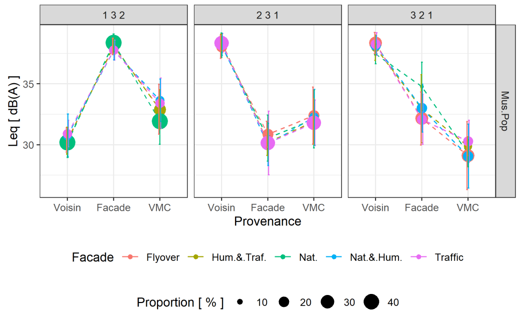
Figure 7: Correlation diagram from the PCA carried out for the subset for which are involved with(a) the sounds of pop. music, (b) the sounds of classical music.

3.3.2 Mean quantification L_{Aeq}

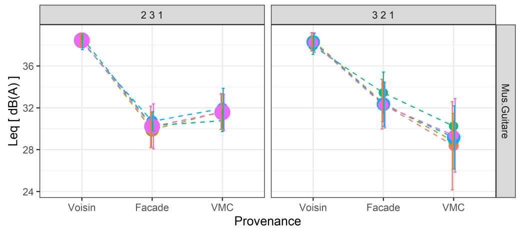
Pop. music: Thanks to the analysis of the diagram presented in Figure 7a, 3 main strategies have been found out. Based on this repartition, mean results for each of the three subgroups are presented in Figure 8a showing the equivalent sound levels per sound source according to the subgroup strategy. The first group increases the level of popular music by about 3 dB(A) in average depending on the combinations. This group of participants is then divided into two sub-groups according to the orders "2 3 1", and "3 2 1". One subgroup prefers to compose the sound scene with more ventilation than facade sounds while the other prefers the opposite. The level differences are always less than 2.5 dB (A) between these two tracks (Facade and Ventilation). The second group of participants has an opposite strategy with regards with the pop. music stimulus. This group lowers the music source level by almost 5 dB (A) in average and prefers (in 90% of cases) to highlight the sounds from outside rather than the ventilation noise in the dwelling. The equivalent sound level of the facade source is in average about 37.5 dB(A).
Classical music: For this last musical stimulus, the results of the optimizations are presented in Figure 8b. The equivalent level $L_{Aeq,30s}$ of the classical music stimulus is always increased to reach on average 38 dB(A), corresponding to an average increase of 3 dB(A) for this track. Then, the two strategies are found out in the choice of the source which will be most present in the mix, either the facade source or the ventilation sounds. The ventilation equivalent noise level is approximately 32 dB(A) when it's preferred. On the other hand, when facade sounds are preferred, the ventilation level becomes lower around 29 dB (A) and that of facade goes up to 32-33 dB (A) in average.

3.4 Impact of the sound optimizations on the perceived pleasantness

This step consists in comparing the two created sound compositions for each configuration of sources as described in section 2.5. The objective of this step is to measure whether the participants manage to create significant differences in pleasantness between the two optimized compositions or whether, despite their attempts, these combinations do not significantly improve their perception. The results of these assessments for the 30 pairs of sources (Neighbour / Facade) are presented in Figure 9. If



(a) Pop. music Ed Sheeran



(b) Classical music

Figure 8: Most pleasant optimizations when the sounds of music from the neighbour are involved. Average results for the equivalent sound levels according to the 2 main points of view with (a) the sounds of pop. music, (b) the sounds of classical music.

the participant clearly discriminates between the two compositions, the result must be negative. On the other hand, if the result is close to zero, this indicates that despite their attempts, it was not possible to create a significantly more pleasant sound environment. Finally, if the participant's assessment is positive, this indicates that he is wrong to recognize the two compositions. Several results emerge from the analysis of variance. In order to characterize the significant differences between pairs of sound stimuli, a repeated measure ANOVA with two factors is performed. The two factors studied are the two variables describing the sound sources according to their origins: the neighbour and the facade. Their interaction is also assessed. The results are presented in the Table 2.

Effet	F test	GES	p-value	
Neighbour	5.33	.01	.0002	***
Facade	17.13	.03	<.0001	***
Neighbour:Facade	2.45	.02	.004	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
GES: Generalized Effect Size

Table 2: Repeated measure ANOVA on the results of pleasantness comparison per pairs of optimized stimuli.

Since the effects of each of the factors and their interaction are significant, a post-hoc test of pair comparisons are carried out with the calculation of the marginal means. Results are presented with the 95% Intervals of Confidence (IC) in Figure 9.
The improvement thanks to the optimization exercise is larger when the sound source of nature is present in the combination, compared to the improvement with other fa-

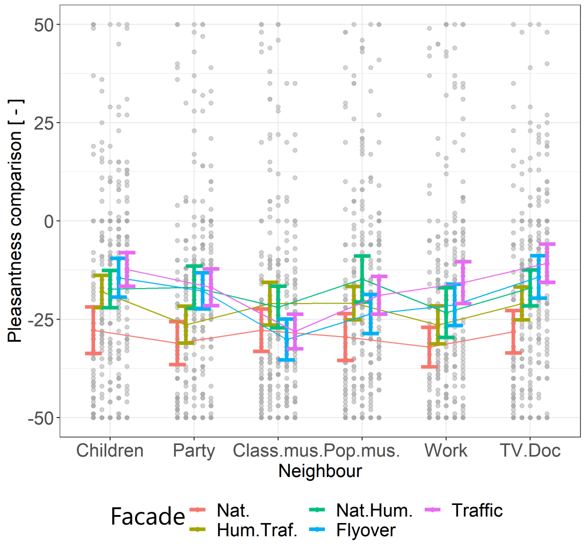


Figure 9: Estimated mean pleasantness comparisons and IC 95% from the post-hoc analysis based on "emmeans" calculations. -50 = Much less pleasant ; +50 = Much more pleasant. Individual participant responses are represented by circles in shades of grey.

cade sounds. A similar trends is obtained with classical music compared to other neighbour sounds. Whatever the source of the facade it was mixed with, the distributions have in absolute high means. On average, the participants managed to significantly improve their pleasantness evaluations by increasing the sound level from of classical music coming from the neighbour.
In contrast, when the traffic stimulus is involved in the combinations, the pleasantness improvement by optimizing the sound tracks becomes weak with average differences $|\Delta| \leq 20$ in most cases (with the exception of the mix with classical music). The traffic source was evaluated during the first pre-test as the second most unpleasant stimulus coming from outside the building [1]. In the same way, when party sounds are involved and associated with sounds of aircraft flyover, traffic or a combination between sounds of nature and human presence on the street, the difference in pleasantness between the two optimizations is limited to -20. This implies that for sources with a higher unpleasantness potential, the composition of optimized sound environments is more difficult. The difference in pleasantness between the two optimizations becomes then tenuous.

4. CONCLUSION

The analysis of the different PCA showed that for 4 of the 6 evaluated neighbouring intrusive sound sources, a consensual choice is found for the composition of the most pleasant sound environments. These optimizations are obtained by reducing the level of the neighbour's source by 4-5 dB (A) on average for the benefit of the others (Ventilation or Facade). Two strategies have then been highlighted with participants preferring to mask the neighbour sound source with the interior ventilation and other participants preferring to use the source of facade to do so. The preferred sound masking source reaches on average an equivalent level L_{Aeq} of 38 dB(A). Intrusive sounds coming from the neighbours are no longer perceived ($\Delta \geq 6\ dB(A)$).

For the two neighbouring sound sources consisting exclusively in music (classical, or pop.), specific strategies have been highlighted. For the source of classical music, 90% of the individuals preferred to increase its gain by 3 dB(A) in average. About 50% of them mixed it with the interior ventilation, and 50% mixed it with the facade sound source. Regarding the popular music sounds, one group reduced its level by 5 dB(A) in average and masked it with the different sources coming from the glass facade. In contrast, individuals who appreciate this stimulus have increased its noise level by about 3 dB(A) in average and have mixed it either with the ventilation (for half of the participants enjoying this kind of music) either with the facade sources (for the other half of this same group).

Finally, thanks to the compositions of the most pleasant sound environments, in all situations, the semantics are changed so that it significantly improves the pleasantness feeling. This result is even more obvious when the sounds of nature or classical music are involved. The influence of the semantics is then confirmed. At the same equivalent sound level, significant differences in pleasantness are highlighted. The superposition of sound sources from the neighbour, the exterior and the accommodation highlights how significant are the sound masking effects when it comes to domestic sounds. But these masking effects were not perceived uniformly according within the panel of participants. For example, the use of ventilation as a masking sound source can improve the pleasantness perception or even degrade it according to individual preferences. Finally, since the main listening test aims to assess sound insulation performance effects on the comfort perceived by inhabitants (See description in section 1), the selection of sound sources must be carried out in maximizing the test power. This leads to a selection of rather consensual sound sources. Thus, the influence of the ventilation has not been studied in the main test.

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