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## **Soundscape design for management of behavioral disorders: a pilot study among nursing home residents with dementia**

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### **ABSTRACT**

**For nursing home residents with dementia, the decrease in communication skills and in social interactions might lead to an increased isolation and can result in a higher risk of behavioral and psychological symptoms of dementia (BPSD). In the framework of the AcustiCare project, five nursing homes in Flanders (Belgium) are participating in the development and testing of specifically designed soundscapes aiming to improve the quality of care and reduce BPSD in residents. Co-creation sessions with staff and family members were organized in the participating nursing homes to manage the acoustic environments that residents will likely be exposed to in their bedrooms and living rooms. The sessions resulted in a 24-hour schedule with alternation of existing sounds, added sounds and silence, which was then delivered in both bedrooms and living rooms with the help of active**

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**systems. The sounds were purposively selected to promote the enhancement of safety. This study presents the progress of a pilot experiment with this purpose.**

## **1 INTRODUCTION**

Care facilities are receiving increasing research attention worldwide. Such interest deals with both the functional and visual settings of their living spaces, and other intangible aspects such as thermal and acoustic comfort<sup>1-4</sup>. Little attention has been paid to the acoustic environments of these spaces so far and they are becoming more important in the debate about the quality of life for both residents and staff members<sup>5-7</sup>.

The AcustiCare project has a focus on the group of older people with dementia residing in nursing homes that are experiencing behavioral and psychological symptoms of dementia (BPSD). BPSD have a significant impact on the Quality of Life (QoL) of older people and their environment and on the quality of work of health professionals<sup>8</sup>. Five nursing homes in Flanders (Belgium) are project partners, together with manufactures/installers of acoustic products, acoustic consultants and public institutions from the building industry<sup>9</sup>. By using the soundscape approach<sup>10-12</sup>, the project aims at: increasing the QoL of older people in the residential care centers; reducing the BPSD; reducing the burden of caregivers.

The methodology is twofold: on the one hand the project aimed to characterize “objectively” the acoustic comfort in the nursing homes by performing room acoustics and sound insulation measurements, and subsequently implementing a number of acoustic retrofit interventions<sup>13</sup>; on the other hand the project also promotes a “subjective” investigation of the sound environments by carrying out sound perception surveys and focus groups both on site and off site<sup>14</sup>, and subsequently implementing different soundscape design strategies, through active systems (i.e., loudspeakers). This paper deals with the latter aspect. For this purpose, firstly a focus group was organized with a heterogeneous group of professionals from the five nursing homes, followed by a co-creation session with (other) staff and family members were organized in two of the five participating nursing homes, in order to define a strategy for the management of the acoustic environments that residents would likely be exposed to in their bedrooms and living rooms. The sessions resulted in a 24-hour schedule with alternation of existing sounds, added sounds through loudspeakers and “silence”, which was then delivered in rooms of interest.

## **2 METHODS**

### **2.1 Soundscape co-creation**

With the objective to obtain appropriate soundscapes for the nursing homes, co-creation sessions were organized on site (Figure 1). For these sessions the different stakeholders including residents (without dementia) and participants of the staff and family were invited to participate. The group participation and the interdisciplinarity of these sessions are important to support the development, broad acceptance and the use of the soundscapes.

The co-creation sessions consisted in the following parts:

Session one:

- An introductory part where the concept of a soundscape was introduced and the dimensional aspects of the Axelsson's soundscape model (pleasantness and eventfulness)<sup>15</sup> were explained. In order to account for personal related aspects four distinct *Personae* were introduced. The use of these *Personae* facilitated the following creative parts in the sessions, making the participation of residents and informal caregivers more accessible.
- An interactive part with the focus on the aspects of the daily pattern to result in an indicative daily pattern time schedule of the soundscape.

Session two:

- An introductory part with a refreshment of the first session (the *Personae* that were discussed, the daily pattern to be supported by the proposed sounds).
- An interactive part with listening sessions where audio samples of different origin were presented. The participants were asked to think about a calm/vibrant soundscape for a specific *persona* and to evaluate in this way the samples to be used as auditory stimuli in the final day pattern.

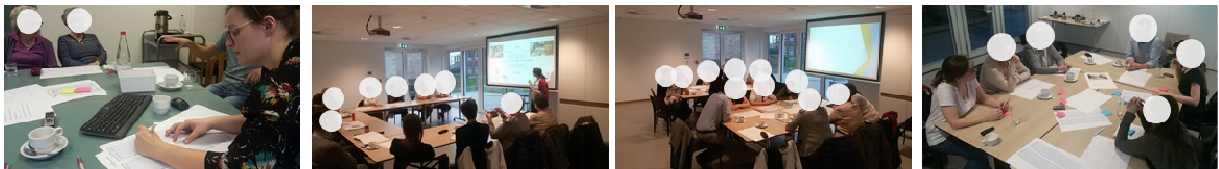


Fig. 1 – Participants during the co-creation sessions

## 2.2 Soundscape playback

After the co-creation sessions the resulting time pattern and the auditory stimuli were combined to obtain a 24-hour soundscape composition. One of the five nursing homes of the project was selected as pilot for the installation of the playback devices.

In order to deliver this composition in the different rooms a dedicated audio player was developed. The system consists of a Raspberry Pi computer with a Wolfson audio card and connected to a pair of MX Sound (Logitech) loudspeakers. The developed software of the system allows for the composition of the soundscape starting from the selected auditory stimuli, and is able to play the 24-hour schedule. In the current version no intervention of the staff is needed to deliver the soundscapes.

The soundscapes were played during seven consecutive days in the bedroom of two residents and in the living room where the residents mainly resided during daytime. The sound levels were adjusted to obtain a level of 65 dBA one meter away from the loudspeakers for a reference pink noise signal.

### 3 RESULTS

#### 3.1 Auditory stimuli

Seven audio excerpts were selected to be used for the daily pattern (described in Section 3.2). These were: Birdsong (bird signing in natural context, light natural sounds as background); Wind (light breeze in natural context and sounds of leaves rustling in the trees); Bell (bell of a church marking 9 o'clock); Cafeteria (sounds of people chatting and cutlery) Typewriter (sound of a person writing, using a typing machine and little bell); Music ("Claire de lune" – Debussy); Heartbeat (sound of heartbeat with a rate of approximately 60-80 bpm). The seven audio excerpts selected during the co-creation sessions had all different durations and relative sound levels. Figure 2 shows the spectrograms of (part of) the audio files and the pink noise used for calibration during the installation of the devices. Considering that the pink noise had an equivalent sound level of 65 dBA at one meter from the loudspeakers, the remaining seven spectrograms represent the relative levels at which the audio excerpts were reproduced.

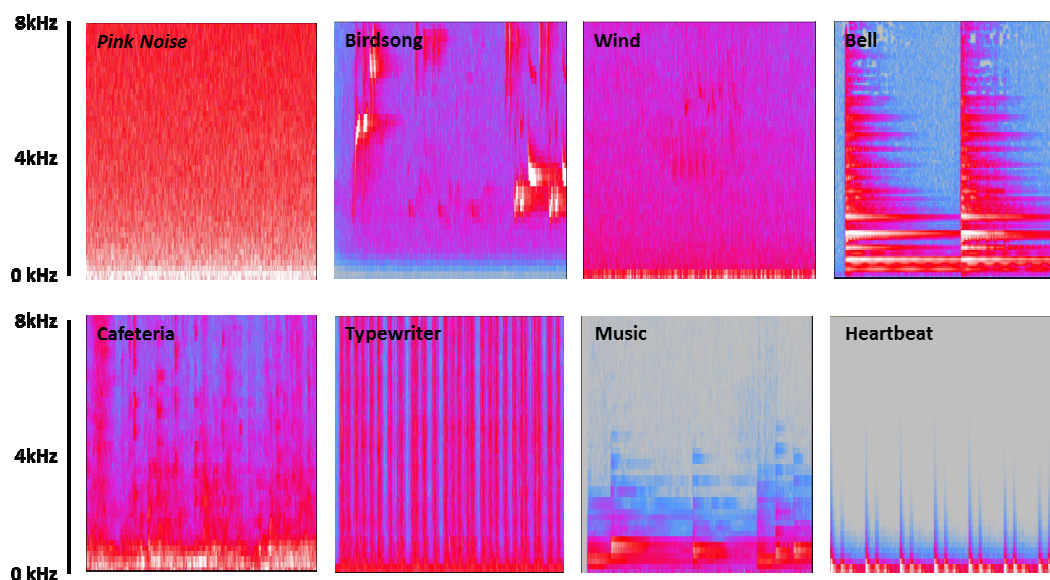


Fig. 2 – Spectrograms (time vs. frequency) of the seven auditory stimuli and the pink noise used for calibration for the soundscape intervention. Each spectrogram represents five seconds, as an example.

On the other hand, for representation purposes in this paper, the audio excerpts were also subsequently equalized to have an A-weighted equivalent sound level of 65 dBA, like if they were all reproduced to render the same sound pressure level. Figure 3 shows that most of the sounds used during the central hours of the day have levels ranging approximately between 40 and 70 dBA across the frequency spectrum. Interestingly, the two sounds used to “start” and “finish” the day show a remarkable x-shaped pattern around the 500 Hz, with the former (i.e., Birdsong) having a very low contribution in the low frequency range and higher contribution in the high frequency, while the latter sound (i.e., Heartbeat) presents most of its contribution in the low frequency range, with little energy in the high frequency range. The pink noise (used for the calibration onsite) was also reported as a reference.

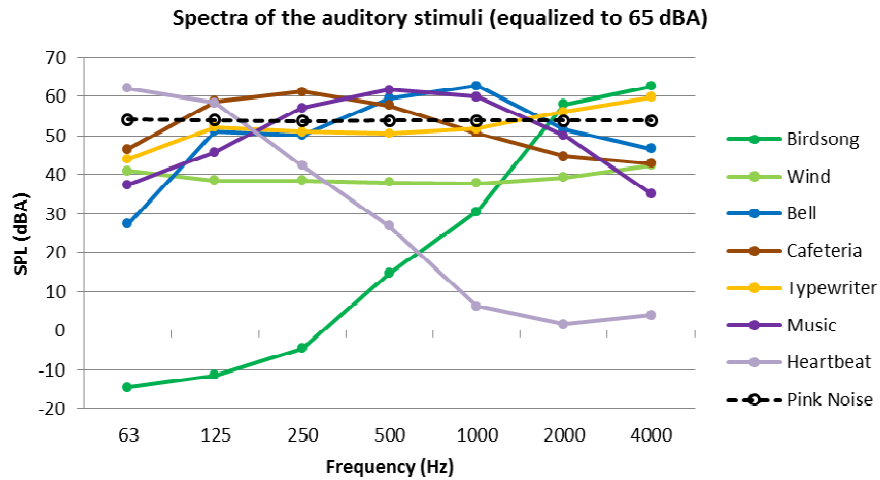


Fig. 3 – Octave bands' spectra of the seven auditory stimuli selected during the co-creation sessions

Table 1 presents the main psychoacoustic parameters, such as Loudness, Fluctuation Strength, Roughness, Sharpness and Tonality<sup>16</sup> calculated using the Artemis software (v.11 - HEAD acoustics GmbH) for the seven stimuli of the co-creation sessions.

Table 1 – Psychoacoustic parameters for the stimuli selected during the co-creation sessions.

Stimuli	A-weighted equivalent sound level normalized to 65 dB for all stimuli				
	Loudness (soneGF)	Fluctuation Strength (vacil)	Roughness (asper)	Sharpness (acum)	Tonality (tu)
Birdsong	5.78	0.0487	0.241	4.05	0.014
Wind	5.30	0.0153	0.010	3.08	0.002
Bell	9.37	0.0408	0.307	2.35	0.456
Cafeteria	10.80	0.0352	0.484	1.78	0.128
Typewriter	13.40	0.2920	1.340	3.58	0.029
Music	6.84	0.0355	0.275	1.07	0.480
Heartbeat	1.11	0.1960	0.170	3.25	0.012
<i>Pink Noise</i>	<i>15.90</i>	<i>0.0168</i>	<i>0.594</i>	<i>3.22</i>	<i>0.018</i>

### 3.2 Daily pattern

According to the focus group and co-creation sessions, it was assumed that an applied soundscape needs to be in accordance with the activity pattern in the nursing home. Since a nursing home is an institution where staff is interacting with residents in order to fulfil the assistance and care needs of the patients, the planning of these tasks needs to be taken into account. The resulting daily pattern from the co-creation sessions is shown in Figure 4. It is important to notice that some time slots of the day were deliberately left without added sounds upon request of the co-creation participants. This is because, for instance, during some moments of the morning a lot of sound-producing activities are already taking place, or else because for some parts of the afternoon, the caregivers aim for a quieter or more silent soundscape. Considering the Loudness, its daily pattern shows a gradual increase starting in the morning with

the Birdsong, reaching a maximum level in the afternoon with the Typewriter stimulus and decreasing towards the night.

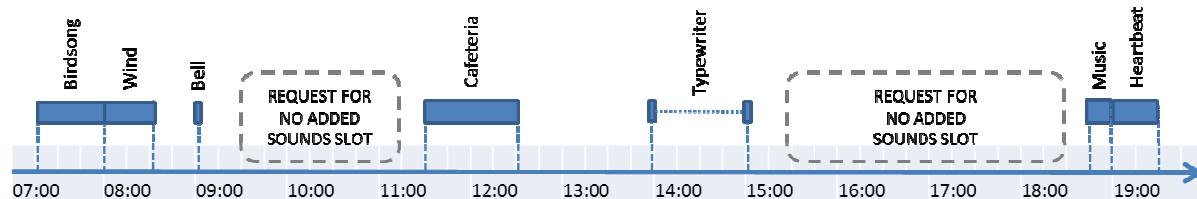


Fig. 4 – The soundscape daily pattern derived after the co-creation sessions

### 3.3 Soundscape aspects

The main purpose of the soundscapes lies in the potential to affect the behavior of the residents. As this behavior is the result of the interpretation on the cognitive level of the different sensory stimuli a resident is experiencing, the auditory stimuli are intended to work in this way. Three main modes of appraisal can be considered:

- In a first mode they are intended to improve the perception of safety by providing repeated information about the current time and about the current place. The Bell auditory stimulus is a clear example of this.
- In a second mode the stimuli are intended to influence the mood of a resident. Music has been used in this way<sup>17</sup>, and music therapy as special individual sessions with individual residents is a common practice in different nursing homes. The Music stimulus used in the late afternoon is included with this purpose. Recently a resulting positive mood has been shown to give an additional positive effect of a broadened scope of auditory attention<sup>18</sup>.
- In a third mode the stimuli are intended to stimulate a specific action of the residents. The stimuli can be seen in this way to give a certain degree of a conditioning reaction. For instance, in our present soundscape design, the Heartbeat stimulus is intended to improve the sleep of the resident, the Cafeteria stimulus is intended to stimulate the orientation in time and as such improve the food intake.

All such modes should be considered in the context of listeners with potentially relevant cognitive impairment and/or capability to properly interpret the “meaning” of the sounds. For this reason, relatively simple sounds were proposed (both temporally and spectrally) to keep the information load for residents to acceptable levels and overall provide as much indicators as possible of “audible safety”<sup>5</sup>.

## 4 CONCLUSIONS

In order to reduce BPSD and improve QoL of NH residents with dementia, an experiment was conducted to use actively played soundscapes to manage these behavioral problems. While many auditory stimuli are known by the general public and are widely used for individual purposes, a soundscape makes it possible to integrate these stimuli in the acoustical environment in a way continuous benefit can be obtained. Using co-creation sessions a 24-hour soundscape composition in accordance with the nursing home organization was defined. Was developed and

appropriate acoustic stimuli were selected to be incorporated. The selected stimuli reflect distinct aspects with the potential to improve the behavior: enhancing the perception of safety, improving the mood and stimulation of specific reactions. Although benefits can be expected further research is needed to clearly demonstrate the potential of the use of soundscapes, and more specific to obtain guidelines for successful implementation.

## 5 ACKNOWLEDGEMENTS

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