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Exploring the soundscape quality of five nursing homes in Flanders (Belgium): preliminary results from the AcustiCare project

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ABSTRACT

Soundscape is the psychological construct resulting from the perception of an acoustic environment in context. While the concept has mostly been referred to 'urban' situations, it does apply to indoor contexts, and particularly to facilities like nursing homes, where specific caring functions are taking place. Recently there has been an increasing interest on the acoustic environment of care facilities and its potential to affect the experience of residents with dementia. There is evidence that poor soundscape quality affects negatively the quality of life of people with dementia and increases agitation. The AcustiCare project aims at using the soundscape approach to enhance the Quality of Life (QoL) of residents and to reduce Behavioural and Psychological Symptoms of Dementia (BPSD), as well as improving the everyday experience of nursing homes for both residents and staff members. In order to characterise the perception of the current acoustic environments, five living rooms in different nursing homes in Flanders were observed during a twelve-hour slot (07:00-19:00h) in a typical week day. Soundscape data were gathered every 30 minutes through a protocol adapted from soundscape literature. Preliminary results show that soundscape quality varied significantly between nursing homes (p<.001 for overall soundscape quality and appropriateness), but not over time during the observation periods (p=.817 and p=.935 for overall soundscape quality and appropriateness). This suggests that much depends on the nursing home but also that there is room for improvement for the soundscape daily pattern and time-varying soundscape strategies might be put in place to manage the acoustic environments of the nursing homes in order to improve the overall residents' experience.

Keywords: Soundscape, Indoor sound quality, Nursing homes I-INCE Classification of Subjects Number(s): 56; 63

1. INTRODUCTION

Soundscape refers to the human perception of an acoustic environment in context (1). While the concept has attracted an increasing interest in urban studies, and outdoor environments more in general, it also applies to indoor contexts, and particularly when these serve 'public' functions, like service buildings, public libraries, transportation hubs, restaurants or other commercial facilities (e.g., 2-4). Within this framework, places like hospitals, care facilities or nursing homes are of utmost relevance, since they often deal with 'vulnerable' users, like older adults or people with intellectual disabilities. There are relatively few examples of research investigating the soundscape quality of nursing homes. In general, there is also a lack of awareness of the importance of the 'quality' sound for the Quality of Life (QoL) in daily care, even if research has pointed out that this depends on 'pleasantness' and

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'safety' rather than 'objective' sound levels (5). Van den Bosch et al. have indeed claimed for further research attention on the role of sound and its potential to reduce behavioral problems in such environments to enhance the quality of life of residents (5,6).

Behavioural and Psychological Symptoms of Dementia (BPSD) are commonly understood as symptoms of disturbed perception, thought content, mood, and behaviour, which frequently occur in people with dementia. The AcustiCare project started in October 2016 with the aim of using the soundscape approach to enhance the everyday experience of nursing homes for both residents and staff members. For this purpose, five nursing homes in Flanders hosting people with dementia were involved in the project. One of the first objectives of the research project was characterising the perception of the acoustic environment of the living rooms to get a preliminary overview of the soundscape quality in those spaces. The living rooms - usually hosting 15-25 people at the time - are the key spaces for the functionality of the facility, because it is the context where people spend most of their daily life and undertake daily activities such as eating, drinking coffee, having social talks, playing games, etc. Hence, it seemed reasonable to start from these environments. The main objective of this paper was exploring the soundscape quality of the nursing homes; in particular, the specific goals were: (a) to investigate if there are significant differences in terms of soundscape quality between the five nursing homes of the project; and (b) to explore whether the soundscapes of the nursing homes vary substantially during a typical day of use. For this scope, a soundscape data collection campaign was organised in each facility using a revised version of a soundscape protocol available in literature. Due to confidentiality issues, the five nursing homes will be referred to in this paper with letters from *A* to *E*. This research project was granted ethical approval through the Commission for Medical Ethics of the Faculty of Medicine and Health Sciences at Ghent University (ref: 2016/1501).

2. METHODS

2.1 Questionnaire

The questionnaire used to gather soundscape data was a revised version adapted from different protocols retrieved in the literature, which have been used both for outdoor and indoor contexts (7-10). Although there is still no standard way of collecting soundscape data, such protocols seem to perform quite consistently in representing different soundscape dimensions (11,12). Data were collected using an online form accessed through a tablet provided to the researcher. Table 1 reports the questions used for the soundscape observation. For each item, the researcher had the possibility to express a score on an ordinal scale ranging from 0 to 10.

Table 1 – Questionnaire used during the soundscape observation in the nursing homes

Item	Questions	Extremes of the scale (0-10)
Q1	"Overall, how would you describe the present surrounding sound environment?"	Very bad–Very good
Q2	"Overall to what extent is the present surrounding sound environment appropriate to the present place?"	Not at all–Perfectly
Q3	To what extent do you presently hear the following seven types of sounds? (*Installation sounds*—e.g., fan/ventilation noise, medical equipment, telephone...; *Operational sounds*—e.g., door slamming, trolleys passing-by, kitchen functions...; *Electronic sounds*—e.g., TV, radio, reproduced music, toys..; *Environmental noise*—e.g., transportation noise, construction noise, birdsong, wind, rain, sounds from people outside...; *Human sounds – VOCAL*—e.g., voices, laughter, sounds from individuals in the room…; *Human sounds – NON-VOCAL*—e.g., footsteps, clapping hands, hitting objects...; *Pets sounds*—e.g., birds in a cage, cats, dogs...)	Do not hear at all– Dominates completely
Q4	For each of the ten scales below, to what extent do you agree or disagree that the present surrounding sound environment is… (*pleasant*; *chaotic*; *vibrant*; *uneventful*; *calm*; *annoying*; *eventful*; *monotonous; safe; intimate*)	Not at all–Completely

2.2 Procedure and observation protocol

The same procedure and observation protocol were implemented at the five care facilities included in the project. A researcher covered a 12-hour period of observation, from 07:00 am to 07:00 pm, in one of the living rooms of the investigated facility. Data collection took place on Thursdays, from December 2016 to February 2017, with one day in each facility (i.e., 60 hours of observation overall). The researcher was sitting in the living room, avoiding interacting with staff, residents and their family members and/or friends, when present. Every 30 minutes, the researcher would fill the questionnaire described in Section 2.1, considering the soundscape overall across the last 30-minute slot. Likewise, the researcher would take note of the number of persons present in the living room; small variations to the number of people (e.g., people leaving/entering the living room for short periods) were disregarded. This information was used for further qualitative considerations about the relationships between number of people and some soundscape dimensions. Figure 1 shows a living room in one facility on one moment of the day, from the observation point of the researcher.

Figure 1 – A moment of the observation day in a nursing home, with 1 staff and 2 residents in the living room

The temporal evolution of overall presence of persons in the living room (aggregating staff, residents and family members or friends) as a function of the time slots of the observation period in the different care facilities is reported in Figure 2 for descriptive purposes. Data represent presence 'on average' (i.e., disregarding staff leaving/entering the living room for short periods) during the preceding 30-minute slot (i.e., data point "10:00" represents presence between 09:30 and 10:00 am, and so on). This was assessed by the researcher.

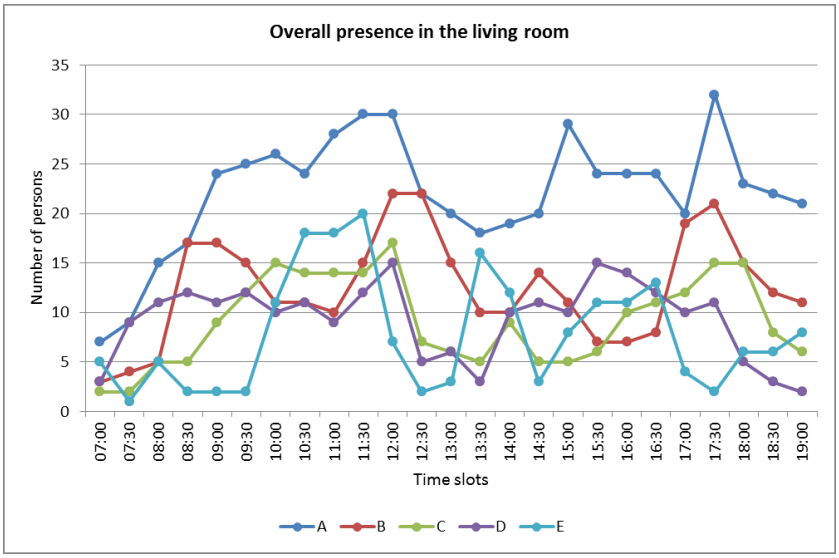

Figure 2 – Overall presence of persons in the five observed living rooms. Data refer to an 'average' number of people as observed in the preceding time slot

2.3 Sound levels monitoring of the living rooms

In order to provide further insights into the acoustic quality of the nursing homes, cost-effective sensor nodes were installed in the five living rooms to continuously measure 1/3-octave band levels, with a temporal resolution of 125 ms. The nodes were installed close to where most activities would take place in the living rooms, but at reasonable distance from specific noise sources which could bias the results. During the observation period, data were sent over the internet to the server infrastructure located in Ghent, Belgium. Data were then further processed using an agent-based approach and stored in a so-called warehouse database. For all data available for each sensor node, the A-weighted sound equivalent level was calculated on a 15-minute basis ($L_{Aeq\text{-}15min}$). Figure 3 reports the $L_{Aeq\text{-}15min}$ for the five nursing homes during the observation periods.

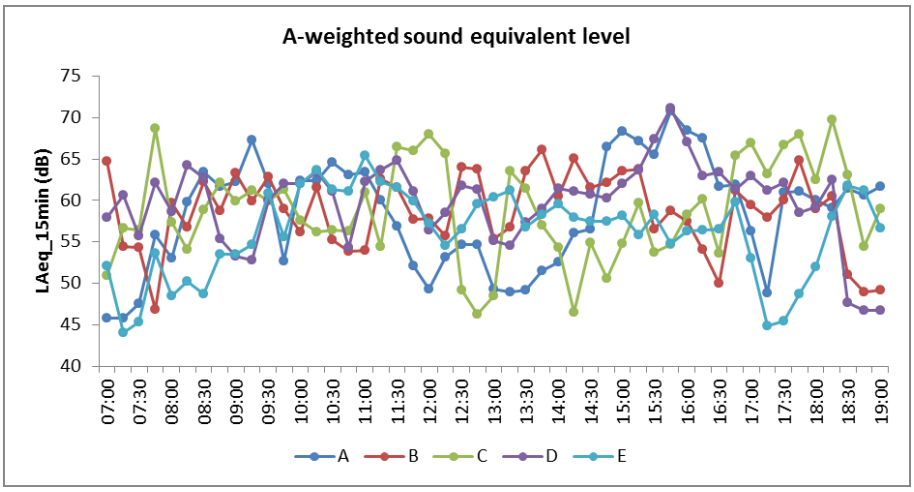

Figure 3 – A-weighted sound equivalent levels in the five observed living rooms. While perceptual data were gathered every half an hour, sound levels have a finer temporal resolution (15 mins)

3. RESULTS

Using the data from the sensor nodes, a one-way ANOVA was conducted to investigate the differences of A-weighted sound equivalent levels in the five nursing homes. $L_{Aeq\text{-}15min}$ scores were statistically significantly different between nursing homes: $F(4, 240) = 2.955$, $p = .021$. However, a Bonferroni post hoc test revealed that only *E* ($M = 56.2$, $SD = 5.1$) was statistically significantly different from *D* ($M = 59.8$, $SD = 4.9$), while no other pair-wise statistically significant difference was observed in terms of sound levels. Figure 4 shows the sound levels dispersion as a function of the nursing homes. From both figures it can be observed that sound levels covered quite a broad range in all nursing homes with slightly higher values in *D* and slightly lower values in *E*.

Regarding the perceptual data, a one-way ANOVA was conducted to determine if, considering all the nursing homes together, the *overall soundscape quality* (Q1, in Table 1) and *overall soundscape appropriateness* (Q2, in Table 1) variables varied significantly over time, thus using the time slot as influencing factor. Figure 5 reports the mean scores for Q1 and Q2 as a function of the time slots. However, no statistically significant differences were observed (p=.817 and p=.935 for overall soundscape quality Q1 and appropriateness Q2, accordingly). As a general trend, quality and appropriateness seem to be particularly low, immediately after lunch (12:30-13:30), possibly when the cleaning activity is more intense.

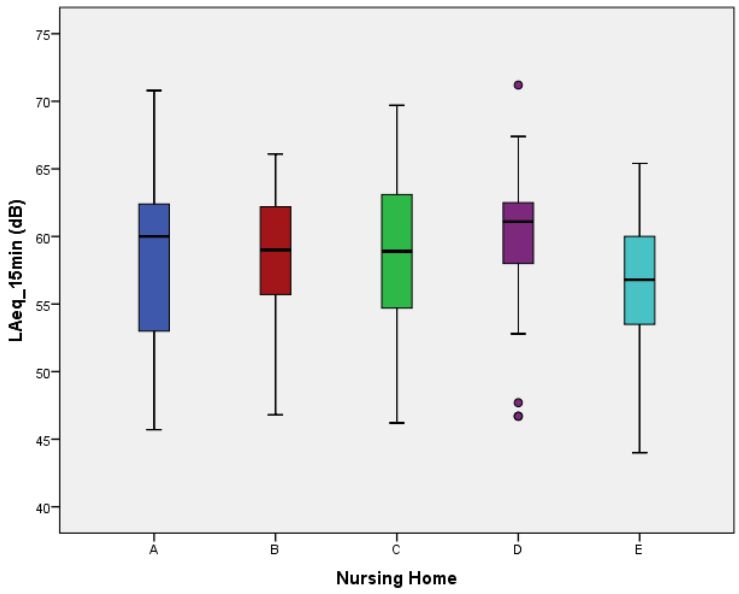

Figure 4 – Dispersions of the A-weighted sound equivalent levels in the five observed living rooms.

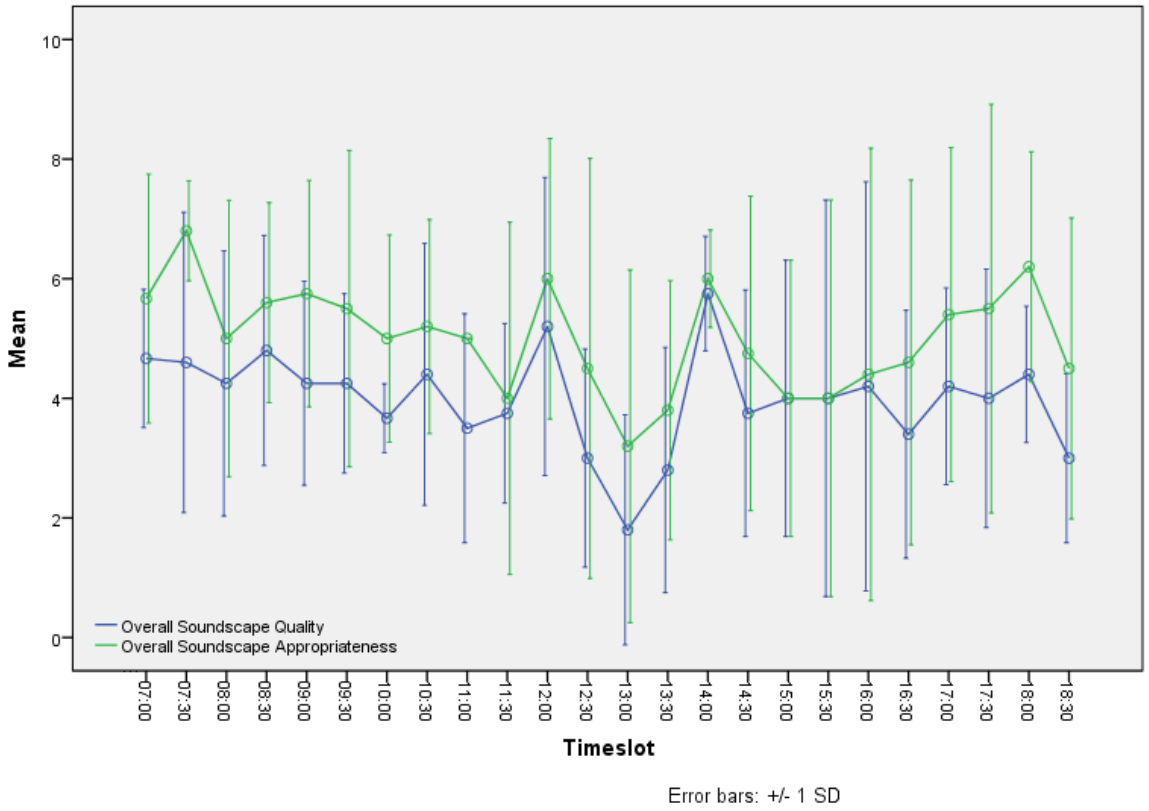

Figure 5 – Mean scores (± SD) of the different nursing homes for the two 'general' questions about soundscape quality (i.e., Q1 and Q2 of the questionnaire reported in Table 1) as a function of the time slots during the observation day

Another one-way ANOVA was conducted to determine if there was a statistically significant difference in terms of *overall soundscape quality* and *overall soundscape appropriateness* between the different nursing homes. Overall soundscape appropriateness scores were statistically significantly

different between nursing homes: F(4, 100) = 16.627, p < .001, and F(4, 100) = 18.280, p < .001, accordingly. Figure 6 shows the mean scores and corresponding confidence intervals for both items Q1 and Q2 in the different nursing homes. Bonferroni post hoc analysis for Q1 revealed that *E* (M = 2.00, SD = 1.11) performed significantly worse than *A* (M = 4.38, SD = 1.71), *B* (M = 5.13, SD = 1.10) and *D* (M = 5.26, SD = 2.07), while *C* (M = 3.25, SD = 1.77) performed significantly worse than *B* and *D*. Likewise, for Q2, Bonferroni post hoc analysis revealed that *E* (M = 2.77, SD = 1.92) performed significantly worse than *A* (M = 5.31, SD = 1.65), *D* (M = 6.13, SD = 2.22) and *B* (M = 6.91, SD = 1.24), while *C* (M = 4.00, SD = 1.93) performed significantly worse than *B* and *D*.

Since no time slot effect was observed, but overall soundscape quality and appropriateness differences between nursing homes did emerge, a further one-way ANOVA was conducted using the nursing homes as influencing factor and the sound sources types (i.e., Q3 in Table 1) as independent variables. Table 2 reports the outcomes of the ANOVA considering each of the seven items in Q3 as independent variable and the nursing homes as dependent variable. It can be observed that the nursing home factor resulted to have a statistically significant effect for all the sound sources categories.

Figure 7 reports the mean scores (averaged over time) of the dominance of the seven sound sources types considered in Q3. All nursing homes show more or less similar profiles, even with different degrees of 'prominence' of the source types. Likewise, Figure 8 shows the mean scores (averaged over time) of the soundscape attributes considered in Q4. It can be observed that the nursing homes *C* and *E* were assessed as related to mostly monotonous and uneventful soundscapes, while the nursing homes *B* and *D* performed particularly well in terms of soundscape safety and intimacy, which are dimensions proved to be extremely important for people with dementia (5, 6, 10).

Moreover, in order to gain further insights about how the presence of people can influence the soundscape quality of the living rooms, the scores for the attributes 'vibrant' and 'chaotic' (two of the ten items of Q4, in Table 1) were plotted against the number of persons in the living rooms, considering all the nursing homes together. The attributes 'vibrant' and 'chaotic' are both related to eventful soundscapes but are opposite on the pleasantness dimension (5). In particular, vibrancy has been often associated to 'social presence' (5). The cubic fit curves reported in Figure 9 show that the soundscapes in the living rooms tended to increase in vibrant scores between 5 and 15 persons (while chaotic scores were low), with a peak around 20 persons. When this amount of people is exceeded, the scores for vibrant decrease, while those for chaotic increase.

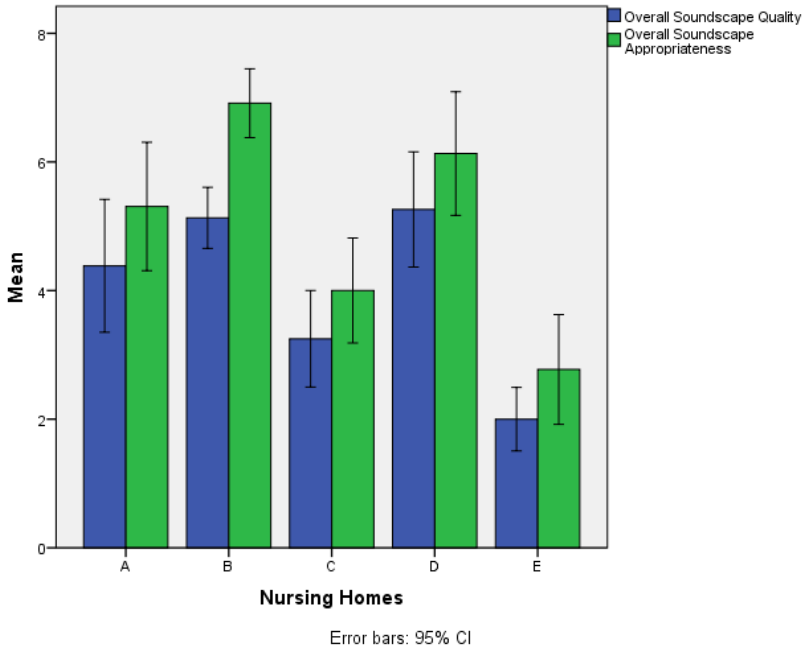

Figure 6 – Mean scores (and confidence intervals) of the two 'general' questions about soundscape quality (i.e., Q1 and Q2 of the questionnaire reported in Table 1) in the different nursing homes

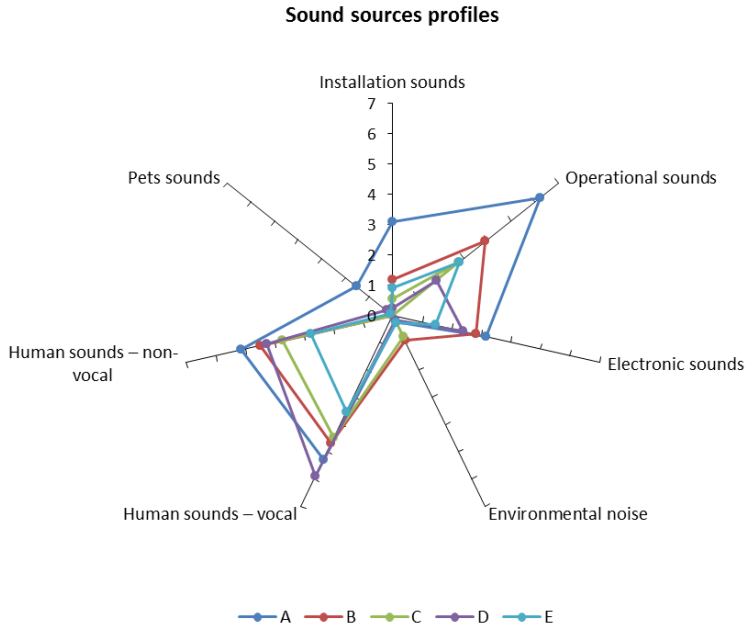

Figure 7 – Mean scores of the dominance of sound sources' types (as per Q3 in Table 1) in the different nursing homes

Table 2 – ANOVA (degrees of freedom: 4 between groups, 100 within groups) for the seven sound sources types used in Q3, considering the nursing homes as dependent factor.

Variable		Sum of Squares	Mean Square	F	Sig.
Installation Sounds	Between Groups	76.08	19.02	10.46	$p < 0.001$
	Within Groups	181.92	1.82		
	Total	258.00			
Operational Sounds	Between Groups	181.39	45.35	16.27	$p < 0.001$
	Within Groups	278.67	2.79		
	Total	460.06			
Electronic Sounds	Between Groups	136.32	34.08	6.87	$p < 0.001$
	Within Groups	495.93	4.96		
	Total	632.25			
Environmental Noises	Between Groups	10.49	2.62	2.92	$p = 0.025$
	Within Groups	89.76	0.90		
	Total	100.25			
Human Sounds (vocal)	Between Groups	68.64	17.16	3.17	$p = 0.017$
	Within Groups	540.92	5.41		
	Total	609.56			
Human Sounds (non-vocal)	Between Groups	58.76	14.69	4.37	$p = 0.003$
	Within Groups	336.23	3.36		
	Total	394.99			
Pets Sounds	Between Groups	25.05	6.26	8.52	$p < 0.001$
	Within Groups	73.48	0.73		
	Total	98.53			

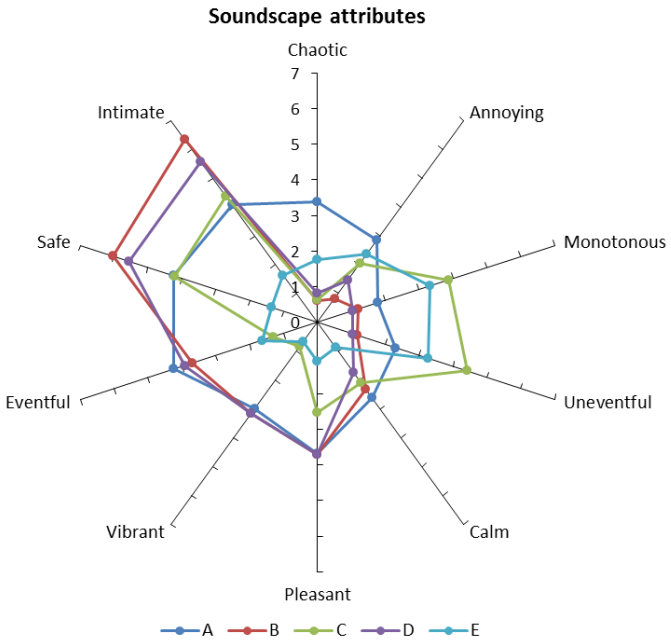

Figure 8 – Mean scores of the soundscape attributes (as per Q4 in Table 1) in the different nursing homes

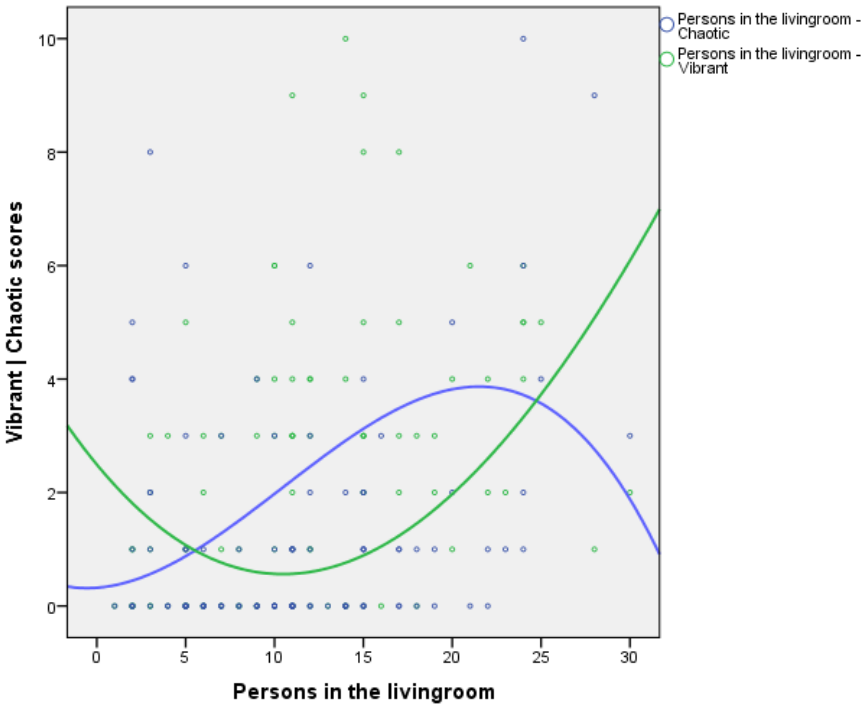

Figure 9 – Scores for the attributes 'vibrant' and 'chaotic', aggregated for all the nursing homes, as a function of the number of persons in the living rooms

4. DISCUSSION AND CONCLUSIONS

This study aimed at characterizing the overall perception of the acoustic environments (i.e., the soundscapes) of the living rooms of five nursing homes in Flanders, during a typical day with residents, staff and family members. The rationale for this is that there are relatively few studies addressing the issue of soundscape quality in such facilities. The main conclusions of this preliminary study are:

(a) Sound levels do not vary significantly between the five nursing homes during the observed periods;

(b) No statistically significant differences were observed in terms of overall soundscape quality and soundscape appropriateness during the day;

(c) Overall soundscape quality and appropriateness differed significantly between nursing homes;

(d) The sound sources profiles of the different nursing homes were statistically significantly different;

(e) The presence of people in the living rooms should be managed carefully, to avoid that vibrant soundscapes become chaotic ones.

Taken together, these results suggest that a nursing home acoustic environment which is rich and varied in terms of sound sources (like in the cases of *A* and *B*) might result in better outcomes in terms of overall soundscape quality.

On the other hand, even disregarding the meaning and information content, an acoustic environment which is 'poor' in terms of sound sources prominence and variability (like in the case of *E*) might not necessarily lead to a good soundscape quality. These findings question the approach that "the quieter, the better", which is also confirmed by the lack of significant difference in terms of 'objective' sound levels.

Several authors have discussed the issues of participation of residents/patients in care facilities through technologies and 'active' tools and how this could enhance their physiological and psychological well-being (e.g., 10,13). Research has indeed shown that implementing psychosocial care strategies instead of using antipsychotics, and training staff members to use social alternatives to drugs in the management of agitated patients with dementia led to a reduced prescription of neuroleptics (e.g., 14). Raising awareness about the potential role of the sound domain in nursing homes is a necessary step towards healthy and stimulating acoustic environments which can promote (and not only permit) better living and working conditions for residents and staff of nursing homes. Active soundscapes, for instance using the residents' sensitivity and preference for specific sounds (10, 15-16), might be a valuable approach for this to be used by the management of such facilities and should be implemented in their daily practice and organisation.

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