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# On the dimension and scaling analysis of soundscape assessment tools: A case study about the "Method A" of ISO/TS 12913-2:2018

Matteo LIONELLO[(1)], Francesco ALETTA[(2)], Jian KANG[(3)]

UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, Central House, 14 Upper Woburn Place, London WC1H 0NN, UK, {[(1)]matteo.lionello.18, [(2)]f.aletta, [(3)]j.kang}@ucl.ac.uk

**Abstract**

Soundscape assessment methods are currently being standardized and semantic differential is a common method used, as reported for instance in the Method A of the ISO/TS 12913-2:2018. However, when applying this method during surveys with non-trained participants, a deviance in scaling adjectives has been observed. This study aims at analysing the distribution of these deviances and possible systematic errors in the scaling. Data were collected through surveys in public open spaces in the UK, Italy and China. Statistical analyses were conducted over the pairs “pleasant-annoying”, “vibrant-monotonous”, “calm-chaotic”, and “eventful-uneventful” with corresponding 5-point Likert scales. The results show a scaling bias effect over adjectives that belong to the same semantic dimension. In particular, participants who gave a neutral evaluation of the adjective “pleasant”, show a systematically greater disagreement with “annoying” whereas the agreement is significantly lower. Similar patterns are observed across other pairs of adjectives. A further analysis revealed that only a small percentage of participants gave an evaluation for each pair of adjectives within a 1-point scale distance.

Keywords: Soundscape, Dimensions, Scaling, Perceptual, Attributes

## 1 INTRODUCTION

During the past years, soundscape has being in course of standardisation. ISO 12913-1:2014[2] defines the term soundscape as the "*acoustic environment as perceived or experienced and/or understood by a person or people, in context*". This follows the former initial definition given by B. Truax in 1978[3]. The definition bases the concept of soundscape on a subjective observation of the acoustical properties of a place[4]. In order to understand the subjective interpretation of the soundscape, it is usually investigated by means of scaling of affective attributes. In the current framework, a particular challenge is to find a set of multidisciplinary indicators[4] (physiological, psychological, psychoacoustical, environmental and contextual factors) to measure soundscapes descriptor based on affective responses[5, 6, 7].

Given a set of scaled attributes for several several observation, dimension reduction methods, such as Principal Component Analysis, are common strategies used to extract the most important attributes used to describe a soundscape. This strategy has been used in 2010 by Axelsson et al.[8], when Russell’s circumplex model[9, 10] has been validated for soundscapes descriptors. The distribution of ratings of adjectives used to describe short soundscape excerpt fall in the two orthogonal dimension of Russell’s model. Valence is so described by the pair of attributes "pleasant-unpleasant" while arousal is turned into "eventful-uneventful". Moreover, the two bisectors of this orthogonal space are identifiable with the two pairs of attributes: "vibrant-monotonous" and "calm-chaotic".

### 1.1 "Method A" of ISO/TS 12913-2:2018

"Method A" of ISO/TS 12913-2:2018[11] describes the methodology of data collection for assessing soundscape based on the rating of 8 attributes. Each of these attribute, also called perceptual attribute (PA), has been asked to be scaled by casual subjects according to what extend each of them well suits the description of a soundscape. The 8 perceptual attributes (PAs) have been chosen according to the semantic meaning of the dimensions of the Principal Component Analysis projection over 116 attributes scaled across 50 soundscape excerpts by 100 students of psychology[12]. 4 pairs of PAs can be formed by selecting for one attribute its semantic opposite one. The scaling of both polar attributes in each pair has been first argued by observing that complex acoustic environments can be perceived simultaneously positive and negative in terms of time-sequences of occurring events. Thus, the two scaling of positive and negative attributes in each pair can be distinguished in two separate tasks. According to the current ISO/TS, this scaling is accomplished by means of a 5-points Likert scale by rating the degree of agreement. In a pilot study, given the rating of a pair of PAs and by reverting the scale of the negative one, it has been seen that only a low percentage of answers falls coherently - meaning that there is null distance between the scores of the two scales. The distribution of these distances across all the subject who completed the survey, shows non-symmetric distribution in many soundscapes. This observation confirms that two scaling within the same pair, are not recognised as the same task. When people are asked to rate their agreement whether a soundscape can be described as *pleasant* or not, they might focus to listen only the positive sound sources, while when subjects are asked to assess the agreement with the attribute '*annoying*' they start to listen only on the negative aspect and so on across all the other pair of perceptual attributes, although the two attributes refer to the same dimension and their scaling should identically overlap.

### 1.2 Processing and analysis of the data

However, this framework lacks of a straight way to process the information collected. An easy strategy to process the information provided by the scaling is to use trigonometric projection[13, 14] onto the 'pleasant-annoying' and 'eventful-uneventful' equivalent axes of Russell's circumplex model:

$$\text{Pleasant} = \sum_{i=1}^{8} \text{median}(PA_i)cos(\theta_i), \quad \text{Eventful} = \sum_{i=1}^{8} \text{median}(PA_i)sin(\theta_i) \tag{1}$$

where median($PA_i$) is the value of the median over the scaling for the $i_{th}$ perceptual factor vector $PA_i$ and $\theta_i$ is the angle on the circumplex plane yield between the 'pleasant-annoying' axis and the axis of the $i_{th}$ PA: $\theta_i = \frac{2\pi}{8}\text{N}_{PA_i}$ with $\text{N}_{PA_i}$ an integer number 1 to 8 coressponding to the $\text{i}_{th}$ PAs sorted on the circumplex plane.
Academic literature has already been focused over the dependencies between single PA and either psycoacoustic measurements and context information[15, 16]. However, three main points have not been so far consistently studied:

- the limited resolution of the space.
- the assumption of identical weights between the scores of PAs within the same pair.
- the assumption of a linear relationship between the subjects' rating and the coordinates on the circumplex plane.

The understanding of these three points relays on the study of the inter-dependencies between the scaling across PAs within the same pair and between PA of different pairs. The overall rating for each of the $i_{th}$ dimension is the average value between the scaling of its positive and negative attribute, $\text{PA}_{i+}$ and $\text{PA}_{i-}$, in each pair: $\beta_{i,+}\mu(\text{PA}_{i,+}) + \beta_{i,-}\mu(\text{PA}_{i,-})$ with $\beta_{i,\pm} = 0.5$. By considering the distinction between the tasks when considered negative attributes and the positive attributes, and because of the short scale used for the ratings, it is very unlikely to get a full ranging of the circumplex diagram whilst having a very small portion of this filled. By following the hypothesis of the distinction between the tasks upon positive vs negative PAs, it is also really likely to perceive, for instance, at least one pleasant event which will lead to scale the pleasantness as 'agree' because of the poor resolution of the scale. A further point to explain the possible discrepancy coming from equation 1) is that subjects, when asked to scale their agreement to a PA, perform a projection from a n-dimensional space of criteria and sensations to a 5-point Likert scale mono-dimensional space[17]. The understanding of which set of rules governs the projection between these two spaces seems challenging. The answer to this could be found in a closer analysis of the bi-variate distribution of the ratings between attributes

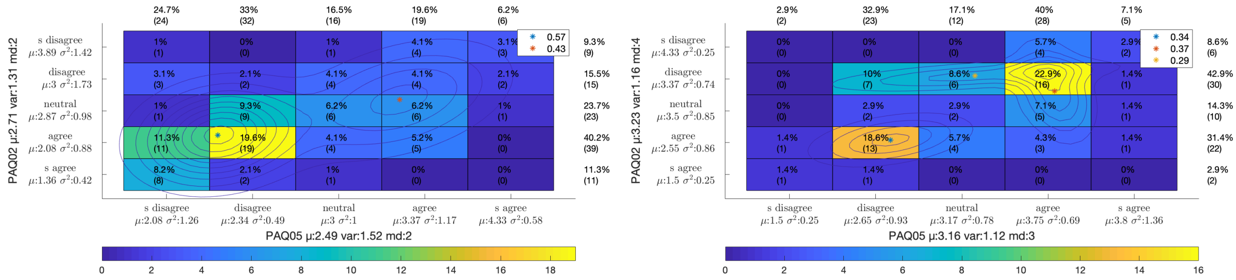


Figure 1. Calm (PAQ05) vs Chaotic (PAQ02) bivariate distribution of scaling from the surveys collected from two sites, one in Venice (left) and one in Shenyang (Right).

which belong to the same pair. This analysis shows that the distribution of answers are often far from fitting a normal distribution showing, in certain cases, also bi-modal behaviours (Figure 1).

These points show some inconsistencies with the above formula, which might tend to be an extreme simplification of the system. This consideration reflects the possibility that the soundscape representation in people minds might not lay onto the orthogonal dimension, or at least they might not share the same scaling. What makes the distributions to be, sometimes, so far from a normal distribution and so different between each other despite of similar overall means and medians? What are the links between similar distributions of ratings with the contextual/physical/psyacoustical environment? What extra information can be extracted from the cross distribution to enrich the current model? The answers to these questions will hopefully be evaluated to extend the current model given in equation 1) to enrich the outcome set of coordinates that describes the soundscape over the circumplex model.

## 2 DATA AND METHODS

### 2.1 Data collection

This study has been run across China, United Kingdom and Italy. Questionnaires have been collected in the same location across multiple days in order to get approximately 100 questionnaires for each location. Dynamics such as changing of weather condition (temperature, wind and brightness) as well as the changing of the context (working days, holidays, people and traffic density, festival and festival duration), actively affect the soundscape. Because of that, data collected on the same site have been studied as different soundscape by different collection date. The soundscapes comprehend two locations in Harbin (China), two areas in a park in Shenyang (China), two location in Venice (Italy), one of them split in 3 soundscapes, and three locations in London (UK). The dataset has been so distinguished in 11 soundscapes. In accordance to 'Method A' in ISO/TS 12913-2:2018, data have been collected through a scaling task of the 8 PAs, namely: 'Pleasant', 'Annoying', 'Eventful', 'Uneventful', 'Vibrant', 'Monotonous', 'Calm' and 'Chaotic'. In the Chinese and Italian sites, the PAs have been translated in the local language by the native speakers within the research team. The attributes have been sorted according to the ISO and they have been scaled in a 5-point Likert scale ranging from 'Strongly disagree' to 'Strongly agree'. Data has been collected from users of the public space. This study received ethical approval in accordance with UCL Research Ethics policy through the procedure implemented at the Institute for Environmental Design and Engineering (Departmental approver's letter on 17th July 2018).

### 2.2 Methods

Statistics dynamics, distances patterns within PAs pairs and correlation of percentage across scaling regions, are aspects which bring important information about how subjects interpret the PAs and the scaling task. In order to investigate these different aspects of the scaling of the perceptual attributes, the following three methods have

Soundscape Pairwise Distances

| | Ss 1 | Ss 2 | Ss 3 | Ss 4 | Ss 5 | Ss 6 | Ss 7 | Ss 8 | Ss 9 | Ss 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ss 1** | - | - | - | - | - | - | - | - | - | - |
| **Ss 2** | 0.74 | - | - | - | - | - | - | - | - | - |
| **Ss 3** | 1.20 | 1.60 | - | - | - | - | - | - | - | - |
| **Ss 4** | 2.05 | 1.67 | 3.01 | - | - | - | - | - | - | - |
| **Ss 5** | 1.75 | 1.89 | 2.64 | 1.65 | - | - | - | - | - | - |
| **Ss 6** | 2.21 | 2.27 | 3.07 | 1.67 | 0.54 | - | - | - | - | - |
| **Ss 7** | 1.80 | 2.00 | 2.61 | 1.70 | 0.40 | 0.71 | - | - | - | - |
| **Ss 8** | 1.95 | 2.19 | 2.66 | 1.91 | 0.64 | 0.72 | 0.46 | - | - | - |
| **Ss 9** | 1.97 | 1.76 | 2.73 | 1.04 | 1.15 | 1.09 | 1.22 | 1.26 | - | - |
| **Ss 10** | 1.37 | 1.25 | 2.15 | 1.10 | 1.08 | 1.30 | 1.08 | 1.23 | 0.68 | - |
| **Ss 11** | 1.14 | 1.46 | 1.41 | 2.17 | 1.42 | 1.78 | 1.39 | 1.37 | 1.56 | 1.09 |

**(Ss = Soundscape abrev.)**

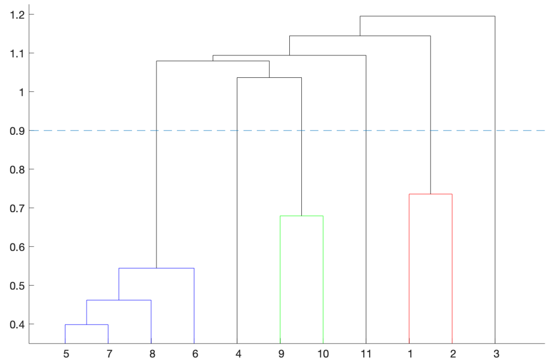


Table 1 (Left) & Figure 2 (Right). Table 1 shows the pairwise eucledian distances between soundscapes across the PA feature space. In the dark grey boxes the two couples of sounscapes with largest distance between each other are highlighted, while the two couples of closest soundscapes are highlighted in a light grey. The Figure 2 shows the Single-linkage clustering performed over the values from Table 1. The horizontal line has been arbitrary placed in the largest zone were no more clusters were added.

been used to analyse the data.

I) Means and variances distribution among the PAs dimensions have been compared between the soundscapes. The comparison of the variances and means helped first to analyse some general trends upon the scaling. The dynamics between positive and negative scaling have been treated by observing the distributions of means and variances for each attribute across all the soundscapes. This helps to understand asymmetric behaviours between negative and positive PAs (see section 3.1).

II) For each survey a new set of features has been introduced by calculating the difference of rating between the positive and negative attributes in each pair, by reverting one of them to make them overlapping consistently. Correlation and p-values have been analysed across these new features. Patterns between distances across two distinct pairs would reveal some redundancy in the interpretation of the task by the subjects. Thus, possible differences over the distribution of statistics across multiple soundscapes can be used to understand the scaling process performed by subject when they decide the score for a PA (see section 3.2).

III) The Likert scale has been split in three zones: disagreement, neutral and agreement including respectively the scaling labels 'totally disagree' and 'to somewhat disagree', 'neither agree, nor disagree', 'to somewhat agree' and 'totally agree'. To highlight some dependencies between PAs a first study shows the correlation on the percentage of agreements, disagreement and neutral rating across all the attributes (see section 3.3).

## 3 RESULTS

Distances between soundscapes have been rendered (Figure 1) by applying hierarchical clustering algorithms, single-linkage clustering, over an eucledian metric across a features space dictated by the 8 PAs. Table 1 shows the pairwise euclidean distances across the 11 sites over the 8 dimensions. As reference values we can observe that a distance of 3.46 units is equal to the distance of two soundscapes spaced by two rating units away along one dimension, while two soundscapes which lay two units away in both pleasant and eventful dimensions are 12 units distant to each other. By giving an arbitrary threshold chosen to fall in the largest region where clusters have not been further distinguished (the dashed horizontal line in Figure 1), it is possible to compose a first cluster of soundscapes including the soundscapes 5, 6, 7, 8, a second cluster which includes soundscapes 9 and 10, a third clusters with soundscapes 1 and 2 while soundscapes 3, 4 and 11 have taken singularly.

Means:

| **Soundscape** | **pl** | not(**ann**) | **eve** | not(**uneve**) | **vib** | not(**mon**) | **cal** | not(**cha**) |
|---|---|---|---|---|---|---|---|---|
| **Soundscape 1** | 3.63 | 3.91 | 3.91 | 3.43 | 3.78 | 4.17 | 2.59 | 2.70 |
| **Soundscape 2** | 3.70 | 4.09 | 3.74 | 3.7 | 3.7 | 4.48 | 2.87 | 3.17 |
| **Soundscape 3** | 3.14 | 3.38 | 4.14 | 4.00 | 3.55 | 4.28 | 2.00 | 2.34 |
| **Soundscape 4** | 4.03 | 4.21 | 3.30 | 3.06 | 3.06 | 3.97 | 3.91 | 3.76 |
| **Soundscape 5**$^*$ | 3.69 | 3.68 | 3.00 | 2.59 | 3.87 | 3.25 | 3.17 | 3.23 |
| **Soundscape 6**$^*$ | 3.83 | 3.65 | 2.63 | 2.40 | 3.65 | 3.15 | 3.33 | 3.35 |
| **Soundscape 7**$^*$ | 3.59 | 3.56 | 3.20 | 2.57 | 3.69 | 3.08 | 3.29 | 3.09 |
| **Soundscape 8**$^*$ | 3.45 | 3.53 | 2.93 | 2.45 | 3.47 | 3.06 | 3.13 | 2.91 |
| **Soundscape 9** | 3.63 | 3.70 | 2.70 | 3.12 | 3.13 | 3.68 | 3.58 | 3.47 |
| **Soundscape 10** | 3.65 | 3.68 | 3.25 | 3.28 | 3.24 | 3.71 | 3.27 | 3.30 |
| **Soundscape 11** | 3.24 | 3.32 | 3.28 | 3.46 | 3.50 | 3.60 | 2.56 | 2.76 |
| $2\sigma$ | 0.50 | 0.55 | 0.96 | 1.08 | 0.54 | 1.01 | 1.06 | 0.80 |
| $2\sigma^*$ | 0.31 | 0.14 | 0.48 | 0.19 | 0.33 | 0.18 | 0.19 | 0.38 |
| $\mu(\mu PA_+ - \mu PA_-)$ | -0.10 | | 0.18 | | -0.16 | | -0.04 | |
| $\mu(\mu PA_+ - \mu PA_-)^*$ | 0.04 | | 0.44 | | 0.54 | | -0.08 | |

Ratio of the variances:

| **Soundscape** | **(pl/ann)** | **(eve / uneve)** | **(vib/mon)** | **(cal/ cha)** |
|---|---|---|---|---|
| **Soundscape 1** | 1.29 | 0.29 | 0.51 | 1.53 |
| **Soundscape 2** | 1.06 | 0.74 | 1.53 | 0.91 |
| **Soundscape 3** | 0.52 | 0.71 | 0.78 | 0.93 |
| **Soundscape 4** | 1.06 | 0.72 | 1.47 | 1.19 |
| **Soundscape 5**$^*$ | 1.03 | 1.64 | 0.81 | 0.97 |
| **Soundscape 6**$^*$ | 0.57 | 1.85 | 1.26 | 1.04 |
| **Soundscape 7**$^*$ | 0.95 | 1.50 | 0.67 | 1.42 |
| **Soundscape 8**$^*$ | 0.67 | 1.66 | 0.97 | 1.41 |
| **Soundscape 9** | 1.00 | 1.19 | 1.01 | 0.96 |
| **Soundscape 10** | 0.86 | 0.95 | 1.27 | 0.94 |
| **Soundscape 11** | 0.77 | 0.94 | 0.91 | 1.30 |
| **mean** | 0.89 | 1.11 | 1.02 | 1.15 |
| **variance** | 0.06 | 0.25 | 0.11 | 0.05 |
| **mean**$^*$ | 0.81 | 1.66 | 0.93 | 1.21 |
| **variance**$^*$ | 0.05 | 0.02 | 0.06 | 0.06 |

Table 2. Left: mean values of each PA across the 11 soundscapes. The scaling of the negative PA (annoying, uneventful, monotonous and chaotic) have been reverted to have a theoretical coherent overlapping with the positive PA. The fourth and third last rows show the $2\sigma$ interval on which the means fall for each PA across all the soundscapes and for a subset of them. Similarly, the second last and the last row show the mean differences between the means of positive and negative PA. Right: Ratio of variances between positive and negative PA are shown across all the soundscapes. Its mean and variances are also displayed in the last 4 rows for the whole dataset of soundscape and for only a subset of it.

The first soundscape cluster refers to all the soundscapes collected in China, the second cluster includes two location in London, while the third cluster gathers two survey collection days out of 3 in Venice from the same location. The single element clusters are the remaining data collection day of one site in Venice, a second site in Venice and a third site in London. Interestingly, the surveys referring to soundscapes 1 and 2 have been collected in two different weather conditions in the same site (sunny, comfortable temperature and low wind versus cloudy, cold temperature and slightly windy). By contrast soundscape 3 from the same location of these two has a similar weather condition of soundscape 1 but it has been taken on one of the last days of a 10 days-long festival in a touristic area. The largest distance between two soundscapes across the feature space is the one ranging between soundscape 3 and soundscape 6. The two soundscapes closest in the feature space are soundscape 5 and 6 recorded in two different days in a park in Shenyang.

### 3.1 Positive vs negative PA: overall dynamics of their respective means and variance

Table 2 shows the distribution of overall statistics across the soundscapes. All the mean values of the scaling of the PAs fall in a distribution centred in 3.38 with variance equals to 0.23. This shows a very narrow distribution of overall soundscape scores across the 11 soundscapes which are approximately centred on the neutral score of the 5-point Likert scale. Across the whole dataset the means are similarly distributed between positive and negative PAs except for the pair *vibrant-monotonous* for which we can see that the mean values of *'monotonous'* fall in a larger range of values compared to the *'vibrant'* means. The mean values of *'cahotic'* are distributed in a range 25% smaller than the means of *'calm'*, while similar figures can be observed between the PAs in the two remaining pairs. Different statistics distribution can be observed on the analysis over a subset of soundscapes. By selecting soundscapes 5, 6, 7 and 8, marked with a "*" in Table 2, it can be observed that the $2\sigma$ interval of the means of positive PAs falls in a range large twice the one for the negative PAs, save for the pair *'calm-chaotic'* for which goes the opposite consideration. They all fall on the agreement area of the positive PA direction except for the pair *'eventful-uneventful'* and the *'cahotic'* score in soundscape 8. The fact that the $2\sigma$ interval is always less than 0.5 means that the soundscapes are all very similar to each other having the means falling on only two neighbouring values of the Likert scale used. Overall variance distribution of the rating have too small differences by considering to the small size of the dataset analysed to have significant meaning except for the pair *'eventful-uneventful'* in the subset '*' where *'eventful'* show a wider spread of a factor $\times 1.66$ in its ratings rather than *'uneventful'*. Across all the soundscapes the pair of PA with highest mean

Correlation of rating distances between paired attributes across all the pairs:

Whole Dataset

| | pl-ann | eve-uneve | vib-mon | cal-cha |
|---|---|---|---|---|
| eve-uneve | 0.04 | - | - | - |
| vib-mon | 0.09* | 0.17*** | - | - |
| cal-cha | 0.07 | 0.00 | 0.18*** | - |
| pleasant | -0.20*** | 0.10* | 0.10* | 0.06 |
| annoying | -0.10* | -0.06 | -0.04 | 0.07 |
| eventful | 0.08 | 0.19*** | 0.1* | 0.04 |
| unevent. | 0.04 | -0.27*** | -0.01 | 0.03 |
| vibrant | -0.04 | 0.12* | -0.01 | -0.03 |
| monot. | -0.04 | -0.09* | -0.21*** | -0.03 |
| calm | -0.06 | 0.06 | 0.02 | 0.03 |
| chaotic | -0.17*** | 0.01 | 0.03 | 0.05 |

Italy

| | pl-ann | eve-uneve | vib-mon | cal-cha |
|---|---|---|---|---|
| eve-uneve | -0.02 | - | - | - |
| vib-mon | 0.13 | 0.09 | - | - |
| cal-cha | 0.04 | -0.02 | 0.28** | - |
| pleasant | -0.39*** | 0.05 | -0.11 | 0.03 |
| annoying | -0.01 | -0.06 | -0.08 | -0.07 |
| eventful | 0.17* | -0.25** | -0.03 | -0.02 |
| unevent. | 0.04 | -0.47*** | 0.08 | 0.09 |
| vibrant | -0.01 | -0.13 | -0.57*** | -0.20* |
| monot. | 0.04 | -0.14 | 0.20* | -0.07 |
| calm | -0.22* | 0.17 | -0.11 | -0.02 |
| chaotic | -0.19* | 0.11 | 0.05 | 0.14 |

China

| | pl-ann | eve-uneve | vib-mon | cal-cha |
|---|---|---|---|---|
| eve-uneve | 0.07 | - | - | - |
| vib-mon | 0.07 | 0.20*** | - | - |
| cal-cha | 0.08 | 0.01 | 0.14** | - |
| pleasant | -0.11* | 0.12* | 0.2*** | 0.07 |
| annoying | -0.16** | -0.04 | -0.02 | 0.12* |
| eventful | 0.03 | 0.40*** | 0.14** | 0.05 |
| unevent. | 0.01 | -0.14** | -0.10 | -0.03 |
| vibrant | -0.05 | 0.21*** | 0.24*** | 0.04 |
| monot | -0.12* | -0.03 | -0.44*** | -0.04 |
| calm | 0.04 | -0.02 | 0.11 | 0.07 |
| chaotic | -0.16** | -0.05 | 0.02 | 0.00 |

England

| | pl-ann | eve-uneve | vib-mon | cal-cha |
|---|---|---|---|---|
| eve-uneve | 0.14* | - | - | - |
| vib-mon | 0.00 | 0.21*** | - | - |
| cal-cha | 0.19** | 0.10 | 0.08 | - |
| pleasant | -0.22*** | -0.02 | -0.04 | -0.02 |
| annoying | -0.15* | 0.02 | 0.03 | -0.08 |
| eventful | 0.08 | -0.32*** | -0.10 | -0.02 |
| unevent. | 0.04 | -0.05 | -0.02 | -0.05 |
| vibrant | -0.01 | -0.16** | -0.37*** | 0.02 |
| monot | -0.06 | 0.02 | 0.12 | -0.04 |
| calm | -0.13* | 0.11 | 0.04 | -0.06 |
| chaotic | -0.11 | 0.12* | 0.02 | -0.12* |

Table 3. Correlation values across the distances between the scores of PAs falling in the same pair. The top-right table and the two on the bottom show the correlation values across subset of soundscape per country. * p<0.05; ** p<0.01; *** p<0.001.

of variance ratio between positive and negative PAs reaches 1.15 across the pair *'calm-chaotic'* while the lowest is 0.89 across the pair *'pleasant-unpleasant'*.

### 3.2 Distances distribution of the scaling and patterns

There are no significant (p>0.05) strong correlation across the distances between paired PAs. The highest significant correlation falls in the subset of Chinese sites showing a weak correlation, equals to 0.28, between the scaling distances between the pairs *'vibrant-monotonous'* and *'calm-chaotic'*. Looking at the correlation figures between one PA and the distance value in its corresponding pair, two different trends are observed: a significant correlation (ranging around 0.3 or larger), and an absent/weak correlation (below 0.25). The highest significant correlation, 0.21, between the distance within a pair and a PA external to the pair is performed in the subset of soundscapes from the Chinese sites across the distance of rating between *'eventful-uneventful'* and the PA *'vibrant'*.

### 3.3 Dependencies across percentage of agreement between attributes

By splitting the scaling labels for each attribute in the classes 'agreement' = 'totally agree', 'agree', 'disagreement' = 'totally disagree', 'disagree' and neutral' = 'neither agree, nor disagree', the correlation between percentage of answers falling in these classes has been studied across adjectives for each soundscape. Table 4 shows strong correlation values across percentages between PAs not belonging to the same pair. In some pair of PAs there is a strong correlation between percentage of neutral scaling and the agreement or disagreement between one PA and its opposite. These figures are shown between, for instance, the neutral evaluation of *'pleasant'* and the disagreement of *'annoying'*. Furthermore it is possible to observe that there is no symmetry between agreement and disagreement between negative and positive PAs (for instance, within PA *'pleasant'*

Agreement-Neutral-Disagremment correlation across attributes:

| | | Pleasant | | | Annoying | | | Eventful | | | Uneventful | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | disagree | neutral | agree | disagree | neutral | agree | disagree | neutral | agree | disagree | neutral | agree |
| Pleas. | disagree | - | - | - | - | - | - | - | - | - | - | - | - |
| | neutral | 0.48 | - | - | - | - | - | - | - | - | - | - | - |
| | agree | -0.83* | -0.89** | - | - | - | - | - | - | - | - | - | - |
| Ann. | disagree | -0.73* | -0.88** | 0.94*** | - | - | - | - | - | - | - | - | - |
| | neutral | 0.2 | 0.71 | -0.56 | -0.5 | - | - | - | - | - | - | - | - |
| | agree | 0.65 | 0.41 | -0.6 | -0.71* | -0.25 | - | - | - | - | - | - | - |
| Event. | disagree | -0.58 | 0.01 | 0.3 | 0.04 | -0.24 | 0.14 | - | - | - | - | - | - |
| | neutral | -0.63 | -0.38 | 0.57 | 0.35 | -0.17 | -0.25 | 0.57 | - | - | - | - | - |
| | agree | 0.68 | 0.19 | -0.48 | -0.21 | 0.24 | 0.05 | -0.9** | -0.87** | - | - | - | - |
| Uneve. | disagree | 0.67 | 0.24 | -0.5 | -0.24 | 0.16 | 0.13 | -0.83* | -0.92** | 0.98*** | - | - | - |
| | neutral | -0.87** | -0.34 | 0.67 | 0.53 | -0.17 | -0.45 | 0.62 | 0.81* | -0.8* | -0.8* | - | - |
| | agree | -0.54 | -0.18 | 0.4 | 0.11 | -0.15 | -0.01 | 0.83* | 0.87** | -0.96*** | -0.98*** | 0.66 | - |
| Vibr. | disagree | -0.24 | -0.33 | 0.34 | 0.37 | -0.71* | 0.16 | 0.11 | 0.09 | -0.11 | 0.01 | 0.31 | -0.12 |
| | neutral | -0.13 | -0.32 | 0.27 | 0.19 | -0.31 | 0.04 | -0.06 | 0.6 | -0.29 | -0.3 | 0.37 | 0.25 |
| | agree | 0.21 | 0.38 | -0.35 | -0.33 | 0.61 | -0.12 | -0.04 | -0.38 | 0.22 | 0.16 | -0.39 | -0.06 |
| Monot. | disagree | 0.48 | 0.06 | -0.29 | 0.02 | 0.1 | -0.1 | -0.85** | -0.83** | 0.95*** | 0.96*** | -0.63 | -0.98*** |
| | neutral | -0.68 | -0.24 | 0.51 | 0.23 | -0.24 | -0.05 | 0.89** | 0.86** | -0.99*** | -0.98*** | 0.75* | 0.97*** |
| | agree | -0.05 | 0.25 | -0.13 | -0.42 | 0.16 | 0.34 | 0.61 | 0.64 | -0.71* | -0.75* | 0.32 | 0.83* |
| Calm. | disagree | 0.86** | 0.61 | -0.84** | -0.7 | 0.46 | 0.41 | -0.58 | -0.83* | 0.78* | 0.79* | -0.94*** | -0.66 |
| | neutral | -0.42 | 0.48 | -0.09 | -0.19 | 0.63 | -0.3 | 0.44 | 0.46 | -0.5 | -0.52 | 0.59 | 0.45 |
| | agree | -0.73* | -0.83* | 0.91** | 0.8* | -0.73* | -0.31 | 0.43 | 0.69 | -0.62 | -0.62 | 0.75* | 0.52 |
| Chaotic | disagree | -0.59 | -0.76* | 0.79* | 0.81* | -0.76* | -0.29 | 0.33 | 0.29 | -0.35 | -0.32 | 0.53 | 0.21 |
| | neutral | -0.58 | -0.01 | 0.31 | 0.1 | 0.31 | -0.36 | 0.36 | 0.7 | -0.59 | -0.64 | 0.67 | 0.57 |
| | agree | 0.9** | 0.66 | -0.9** | -0.77* | 0.46 | 0.5 | -0.53 | -0.72* | 0.7 | 0.7 | -0.91** | -0.57 |

| | | Vibrant | | | Monotonous | | | Calm | | | Chaotic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | disagree | neutral | agree | disagree | neutral | agree | disagree | neutral | agree | disagree | neutral | agree |
| Vibr. | disagree | - | - | - | - | - | - | - | - | - | - | - | - |
| | neutral | 0.49 | - | - | - | - | - | - | - | - | - | - | - |
| | agree | -0.88** | -0.84** | - | - | - | - | - | - | - | - | - | - |
| Monot. | disagree | 0.12 | -0.25 | 0.06 | - | - | - | - | - | - | - | - | - |
| | neutral | 0.04 | 0.25 | -0.16 | -0.96*** | - | - | - | - | - | - | - | - |
| | agree | -0.36 | 0.21 | 0.11 | -0.88** | 0.71* | - | - | - | - | - | - | - |
| Calm. | disagree | -0.43 | -0.45 | 0.51 | 0.6 | -0.75* | -0.24 | - | - | - | - | - | - |
| | neutral | -0.25 | 0.03 | 0.14 | -0.49 | 0.44 | 0.49 | -0.3 | - | - | - | - | - |
| | agree | 0.55 | 0.46 | -0.59 | -0.43 | 0.61 | 0.06 | -0.93*** | -0.08 | - | - | - | - |
| Chaotic | disagree | 0.57 | 0.06 | -0.39 | -0.11 | 0.32 | -0.26 | -0.72* | -0.25 | 0.85** | - | - | - |
| | neutral | -0.15 | 0.41 | -0.13 | -0.61 | 0.61 | 0.5 | -0.52 | 0.69 | 0.27 | -0.18 | - | - |
| | agree | -0.4 | -0.33 | 0.43 | 0.5 | -0.68 | -0.11 | 0.98*** | -0.24 | -0.92** | -0.75* | -0.51 | - |

Table 4. Correlation table among percentage of agreement, disagreement and neutral scaling for each PA across all the soundscapes. * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

there is strong correlation between agreement and disagreement, and between agreement and neutral, while there is any correlation observed between neutral and disagreement).

## 4 DISCUSSION AND CONCLUSION

This paper introduced some inter-dependencies studies across PAs within the framework of "Method A" of ISO/TS 12913-2:2018. First, it has been shown that there are some classes of soundscapes which perform asymmetric distribution across the mean and variances over their PAs. It has also been observed for one of these classes, the means of the positive adjectives fall in a larger interval compared to the means of the negative adjectives. For these soundscapes there also stands a significant deviation in scaling for eventful and vibrant where their means are significantly larger than the means of their related opposite attributes. Secondly, the correlation table over distances between polar PAs does not show high values while, their correlation with their corresponding single PAs shows different trends which might be further analysed in next studies. Finally, correlations across percentage of agreement, neutral and disagreement rating show interesting patterns which help to investigate the way subjects interpret the positive and negative meaning of each pole of the PA pairs.

To conclude, the findings suggest that bi-variate analysis within PA pairs provides an important tool for the understanding inter-dependencies and dynamics and they will be included in future works for further validation.

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