Mapping Workplace Soundscapes: Reifying Office Auditory Environments

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ABSTRACT

This paper reports an empirical study to investigate how individuals perceive and classify elements of their workplace auditory environments. The participants were 18 university employees chosen for their varying degrees of room occupancy, from single occupants through to those sharing with up to 11 colleagues. Participants in single rooms were expected to have greater control over their auditory environment than those who shared, and as such, the desire and opportunity to influence the soundscape could be studied, in both positive and negative terms. A key aim was to discover what terms individuals used when describing sounds, whether they were technical, musical or object-orientated.

Participants were interviewed individually, in their usual office environment, using a series of questions on a variety of topics such as the ideal working environment, and any desire to alter it, as well their experiences with auditory interfaces. After the interview, participants were asked to listen to their auditory environment for 15 minutes and describe what they could hear. Following this, they were asked to classify each sound they had mentioned using a modified version of Macaulay and Crerar's (1998) Soundscape Mapping Method. Subsequently the responses were combined onto a single diagrammatic map for ease of comparison.

The interviews revealed how seldom descriptions of sounds go beyond object-orientated identifications, irrespective of the individual's background, bearing out Ballas and Howard's (1987) experiences when trying to elicit descriptions of environmental sounds. A clear indication from this series of interviews is the reliance on the source when describing sound, as Metz (1985) states, when individuals are describing sounds they are "actually thinking of the visual image of the sound's source". We discuss codes derived from the interview transcripts and revisions made to the soundscape mapping method as a result of our findings.

Keywords

Soundscape, Mapping, Classification, Visualization, Workplace

Background

This study forms part of a larger research project concerned with developing tools and techniques to understand, model and ultimately design auditory environments. Visual interfaces are notoriously over-utilised and the potential of sound has been long recognised, but designers have traditionally found sound to "have a meaning which is communicable and valid but unanalyzable" (Doane, 1985).

A series of 18 interviews were conducted with office inhabitants at Napier University, in order to establish key themes that are important to their perceived auditory environment. After each interview was completed a modified version of Macaulay and Crerar's (1998) method was applied. This method was chosen as it addresses the mapping of auditory environments from a human computer interaction perspective, rather than the more traditional acoustic ecological perspective. The original authors identified "a gap in the research agenda of the auditory display community" and attempted to utilise ethnographic techniques rather than the traditional cognitive science model in order to fill this gap. The method takes the form of a 'context of use' through 'activity' in the form of an 'analytical tool' where each sound event is classified according to its sound type, information category and acoustical information, providing a form of metadata (see Table 1). It also goes further than a traditional Gestalt figure/ground (foreground/background) approach, by introducing a third contextual dimension. This third mediating layer provides contextual information that may direct attention towards foreground events or help to interpret the environment – without itself being the focus of conscious attention.

Sound Type	Example
Music	Any type of identifiable music, radio/stereo
Speech	Any form of speech
Other known	Identifiable sounds
Other unknown	Unidentified sounds
Information Category	**Example**
Visible entities and events	The phone ringing.
Hidden entities and events	The photocopier round the corner being used
Imagined entities and events	Something is happening in the children's room, it has gone very quiet.
Patterns of events/entities	Someone is batch copying a large document
The passing of time	I can hear children coming out of the school gate.
Emotions	The boss is unhappy I can hear his teeth grinding.
Position in Euclidean/acoustic space of entities/events and of the listener	The editor is at the foreign desk behind me (can hear his voice)
Acoustical Information	**Example**
Foreground	Computer beep to attract your attention. (Sounds within the foreground of your experience of the soundscape).
Contextual	Door opening (Help you orient to the nature of your environment.)
Background	Whine of disk drive providing reassurance or information about the state of the world.

Table 1: Macaulay and Crerar's Workplace Soundscape Mapping Tool Questionnaire (modified).

This classification method was originally intended for use by fieldworkers and designers, in order to preview the workplace context creating a rich picture prior to the introduction or development of an auditory interface or system. It was developed during a 12-month ethnographic study at *The Scotsman* (newspaper) offices in Edinburgh, and is based on the work of Ferrington (1994) for the acoustical information as well as Truax (2001) and Chion (1994) for the sound types and information categories. The authors proposed that resulting auditory analyses could used "to add auditory aspects to ethnographic vignettes", as well as providing a shared language that would facilitate comparative studies.

One of the key elements not addressed by Macaulay and Crerar was the end user or inhabitant. Each individual inhabits a unique soundscape, based on a range of physical and psychological factors, experiences and current interests, and as such will provide unique responses to 'the same' auditory environment (in a manner akin to the Rashomon effect of Kurosawa's 1950 film) (Altman, 1992). Maps created by multiple inhabitants can provide a further insight into the typical versus the individual experience. The designer's perspective can then be compared with those of individual inhabitants, or a typical response for a specific environment, or a typical response to a typical room. This would allow an anthropocentric approach to the design of auditory systems suitable for shared auditory environments.

Method

This preliminary study took the form of interviews with 18 participants (*7 private office inhabitants and 11 who shared office space)* in 18 individual locations, resulting in 18 soundscape maps. Participants were all University employees none of whom specialised in sound design or evaluation in any way. Interviews were semi-structured, taking an average of 30 minutes each within the interviewees' offices. Each interview was recorded using a cassette recorder and subsequently transcribed, prior to coding with Atlas.ti software.

The interview started with questions about equipment traditionally associated with an office such as telephones, computers and any other auditory interfaces the interviewee had experienced. It then went on to query the impact of sounds that the participant found attention grabbing, relaxing, stressful and information rich. Questioning finished by discussing the office's auditory environment in general and asking the participant about what they would like to change or control.

Coding took the form of establishing key dimensions; codes were added to relevant quotations using a grounded approach where codes were suggested by the quotations, rather than having established a pre-defined set prior to coding. Once the first pass was completed and the codes were set, a second pass was made in order to ensure that each document was referenced using the full set of codes. At the completion of this second pass, a square root sample of quotations within each code was tested in order to check accuracy.

After each interview, participants were asked to describe each sound they could hear, excluding those made by the interviewer and the cassette recorder. Fifteen minutes was given to this elicitation task. One major consequence was that participants stopped creating any noises themselves in order to listen more carefully, thereby omitting a major contribution to their personal soundscapes. Following elicitation, each sound that had been identified was classified by the interviewee, according to Macaulay and Crerar's modified method (see Table 1), and subsequently visualized as detailed below by the first author (see Figures 1 and 2). In an initial trial (McGregor *et al.*, 2006) the original classification of *abstract* and *everyday* were not consistently applied by respondents, so were replaced for this iteration by *other known* and *other unknown*.

In Figure 1, each concentric circle represents the acoustical information with *foreground* being located in the centre. The seven segments of the circle represent the information categories, as labelled.

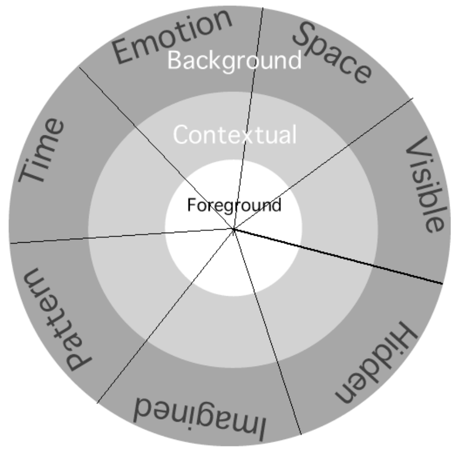

Figure 1. *Pictorial representation of data, based on an original map by Macaulay and Crerar (unpublished).*

The sound type, was notated by the labelling of each 'bubble' with a symbol. *Music* was a couple of notes ♬, *other known* an exclamation mark **!**, *speech* a series of letters **abc** and *other unknown* by a question mark **?**. Sound events were cross-referenced to letters within each 'bubble' to help prevent the image becoming too cluttered by confining the contents to a letter and a symbol, rather than a textual description of the source and event. The visualization did not use colour for individual maps, this was confined to maps with aggregated responses, allowing easy differentiation between the two different types. The individual colours in the latter case represented the quantity of responses for each sound event. Different shapes were also used, to denote whether the sound event was created by the *participant* (circle), or was an *interior* (square) or *exterior* event (polygon). Figure 2 shows how a typical soundscape might look.

Results

The results can be split into two sections: the first is that of the codes applied to auditory descriptions for extending the existing method; the second is the trial of the modified method in order to create soundscape maps representing a typical single occupancy University office, a shared University office and finally a typical University office.

Codes

The resultant codes were subdivided into three main groups (rows in Table 2): those that applied to all of the participants' responses; the majority, and finally those derived from a minority of responses. Within the 100% response group *source* was predominant, it represented any identifiable source that the interviewee referred to when describing a sound. Sources typically fell into living or inanimate categories, providing an object-orientated approach to describing the sounds. Sounds reported were not confined to those inside the office environment. Participants frequently referred to external sources, both from memory and the present, such as 'seagulls' and 'traffic'. Torigoe (2002) also found that 'memories of sounds' are remembered concurrently with sounds that are currently present. Typical sources were described in generic terms such as 'computer', 'telephone' and 'people'. Specific sources were only applied to individual people, rather than objects, even when discussing the shared environment, and a couple of references were made to *material* the sound source was constructed from 'metallic' and 'wood'.

Code	Respondents	%	Instances	%	Rank
Source	18	100%	509	25.66%	1
Type	18	100%	258	13.00%	2
Action	18	100%	205	10.33%	3
Dynamics	18	100%	199	10.03%	4
Onomatopoeia	18	100%	170	8.57%	5
Informative	18	100%	78	3.93%	6
Pollution	17	94%	66	3.33%	7
Spatial	17	94%	60	3.02%	8
Relaxing	16	89%	19	0.96%	9
Arresting	16	89%	18	0.91%	10
Temporal	15	83%	76	3.83%	11
Spectral	15	83%	64	3.23%	12
Natural	14	78%	37	1.86%	13
Environment	14	78%	19	0.96%	14
Stressful	14	78%	17	0.86%	15
Aesthetics	10	56%	31	1.56%	16
Emotions	10	56%	19	0.96%	17
Preference	9	50%	17	0.86%	18
Artificial	8	44%	15	0.76%	19
Content	7	39%	13	0.66%	20
Masking	7	39%	9	0.45%	21
Context	6	33%	20	1.01%	22
Quality	6	33%	8	0.40%	23
Quantity	5	28%	10	0.50%	24
Recipient	4	22%	7	0.35%	25
Clarity	4	22%	5	0.25%	26
Force	4	22%	5	0.25%	26
Pleasure	4	22%	5	0.25%	26
Room acoustics	4	22%	4	0.20%	29
Interest	3	17%	3	0.15%	30
Motivate	3	17%	3	0.15%	30
Evocation	2	11%	4	0.20%	32
Familiarity	2	11%	2	0.10%	33
Material	2	11%	2	0.10%	33
Mechanistic	2	11%	2	0.10%	33
Complexity	1	6%	1	0.05%	36
Dispersion	1	6%	1	0.05%	36
Effect	1	6%	1	0.05%	36
Gender	1	6%	1	0.05%	36
Privacy	1	6%	1	0.05%	36

Table 2: Codes resulting from interview transcriptions.

Type was applied when referring to a more abstract concept without identifying a specific source such as 'music', 'noise' or 'speech'. *Action* included all physical actions, which generated a sound such as 'pouring', 'footsteps' and 'blowing'. *Force* was only mentioned 5 times and could be seen as a subset of *action* or as a clarification. *Dynamics* invariably were detailed in terms of 'silent', 'quiet' or 'loud', alternatives included 'background' when referring to low levels of listening rather than spatial aspects, and 'noisy' when the sound was considered excessive without being directly related to pollution. *Onomatopoeia* was used to cover descriptors that reflected the sound produced, such as 'clanking', 'click' and 'whine'. *Informative* referred to 'signals', 'alarms' and 'cue', sounds which communicated a single state or sequence of information. *Evocation* was referred to when the sound acted as a trigger for what was usually an extensive memory.

The majority of respondents referred to *pollution* relating it to both: pollution created by others as well as the impact the interviewees had themselves on the shared auditory environment. Specific references were made to participants' personal responses, from 'irritating' through to 'annoying' and finally 'hate'. *Spatial* dimensions were always in relation to the interviewee such as 'behind me', 'outside my office' or the even more vague 'out there'.

When *relaxing* sound events were described, terms used included 'relaxing','soothing' and 'peaceful'. This contrasted with *stressful* events which were only referred to with the single descriptor 'stressful'. *Motivate* applied to stimulation, but only with regards to music. *Arresting* covered 'urgency' and 'arousal' as well as 'arresting'. *Temporal* and *spectral,* like *dynamic,* were referred to in binary terms, (*temporal* as 'consistent' or 'occasional', with specific references to times of the day; *spectral* as 'higher' or 'lower' along with generic, 'tone', 'pitch' or 'frequency').

Natural sounds were referred to more commonly than *artificial* or *mechanistic,* despite the questioning taking place in an office. In general terms, the natural sounds were regarded more favourably than the recorded or machine generated one. This result corresponds with Anderson *et al*. (1983) who found that sounds from 'natural sources' were rated more positively than man-made sounds, a result which also borne out by Kageyama (1993).

Aesthetics fell into positive or negative terms rather than passive, with a slight bias towards the negative: 'offensive', 'piercing' and 'discordant' compared to 'lovely', 'daintily' and 'pleasant'. *Emotions* were also expressed with polar responses, based around positive or negative emotions such as 'happy', 'aggression' or 'distress'. *Environment* referred to an identifiable location as the sound source rather than the more generic *spatial*. These included cities, buildings, rooms as well as outdoor locations such as 'rivers' and 'gardens'. *Room acoustics* whilst being rarely mentioned did refer to whether the room affected the sound positively or had poor 'insulation' which was related to pollution. *Preference* was indicated through simple terms such as 'like' or 'dislike', with the more specific *pleasure* related in terms of 'pleasing', or 'amusing'. *Interest* referred to whether the sound was 'boring' or had any relevance, without indicating *pollution*.

The dimensions contributed by minorities of the respondents are probably the more interesting for the sound designer, as they represent responses generally more difficult to elicit from end users. As can be seen from Table 2, 49% of the codes were related to *source*, *type* and *action*. *Content* was applied to verbatim quotes of conversations this differed from *context*, in that the latter provided information about the context in which the listener interpreted the sound, rather than merely reporting it. Whereas *recipient* specifically related whom the sound event was intended for.

Masking referred to sounds which were either generated by the participant in order 'to kill off other things' or sounds which listeners became 'attuned to' thereby masking themselves. *Familiarity* was expressed in terms of 'being used to it' and 'surprising'. *Quality* exclusively applied to the source producing the sound in terms of 'low', whereas *clarity* was related to the sounds themselves, again in negative terms being 'confused' or 'chaotic'. *Quantity* related to either 1 to 3 or 'lots' with no values in between.

The remaining codes only had single instances, but are still notable to a sound designer. *Complexity* in this case 'simple', could be considered part of *aesthetics*. *Dispersion* was related in technical terms as 'unidirectional', and in this case applied to speech. *Effect* referred to a sound being 'used to speed up the heart rate'. The single occurrence of *gender* was surprising, as people were always referred to in generic terms except by name, rather than specifying their sex. Finally, *privacy* could be related to *recipient*, in that the content was not intended for the listener.

Comparison of Codes with Modified Method

Whilst these codes are the basis for a more in-depth analysis of the individual words used during the interviews, in combination with the descriptions listed by the participants for mapping, it is possible to propose a method of classification based on these initial findings, if only to compare it with the modified Macaulay and Crerar method. As illustrated above, many of the concepts are closely related, or extensions of others, a revised method of classification is given in Table 3.

Description	
Source	Name of source including material if relevant
Action	Type of action
Onomatopoeia	Description of sound
Context	Meaning of sound
Type	
Speech	Human
Music	All types
Signal	Informative non speech or music
Noise	Without information content
Physical Characteristics	
Volume	Loud/Medium/Quiet
Pitch	High/Medium/Low
Location	Proximity/Orientation/Dispersion
Movement	Stationary/Moving
Time	Unique/Intermittent/Continuous
Origination	Man-made/natural
Quantity	Single/Multiple
Complexity	High/Medium/Low
Perceptual Characteristics	
Impact	Arresting/Stressful/Relaxing/Stimulating/Evocative/Neutral
Emotions	Positive/Neutral/Negative
Relevance	Interesting/Neutral/Irrelevant/Pollution
Aesthetics	Pleasing/Neutral/Displeasing
Clarity	Distinct/Neutral/Indistinct
Quality	High/Neutral/Low

Table 3: Revised classification derived from codes.

The resultant classification is slightly more complicated than the modified Macaulay and Crerar method (Table 1). A more precise description is required prior to classification as the current model is dependent on what the participant wishes to provide. The sound *type* is very similar sharing *speech* and *music*, with *signal* and *noise* replacing *other known* and *other unknown*.

The physical characteristics are almost entirely missing from the modified Macaulay and Crerar method, although when people described sounds and therefore their perceived soundscape they did refer to its physical dimensions, especially *dynamics* and *spectral*. *Acoustical information* incorporates *volume* to a limited extent but more in the abstract sense of *foreground* sounds being typically louder than *background*. *Pitch* is missing entirely, together with *quantity* and *origination* in terms of *natural* or *man-made*. *Natural* and *man-made* were referred to in the original 1998 paper as *abstract* or *everyday* but responses from participants varied dramatically in an initial study (McGregor *et al.,* 2006) as to their meaning, with some responses based on familiarity and others referring to man-made or natural.

Position is included in the modified method but as a single option within *information category* rather than specifying the *location* in terms of *proximity*, *orientation* and *dispersion*, it also incorporates *movement,* omitting whether the sound source is *moving* or *stationary*. The new classification's '*location'* relates well to Carlile's (2002) "principal dimensions of auditory spatial perception" which were *direction*, *distance* and *spaciousness*. 'Time' is shared by both classifications: the modified method records whether the sound has any temporal significance compared to *unique*, *intermittent* or *continuous* within the revised method.

Patterns in the Macaulay and Crerar method relates to *complexity* and to a limited extent *quantity,* inferring more than one source, within the grouping. *Emotions* are included in both methods but in the revised classification they are separated out into *positive*, *negative*, or *neutral*, rather than just being present. *Imagined* in the modified method relates to *context* which requires a description, rather than acting as a classification.

Two information categories are unique to the modified Macaulay and Crerar method, in comparison to five for the revised method. In the former *hidden* and *visible* refer to whether the origin of the sound can seen or not. This is not in the revised method, as no mention was made by any of the interviewees as to whether they could see the sound source, or it was hidden from their view. *Impact* and *relevance* refer to what effect the sound is having on the listener and whether they consider it relevant or not. *Aesthetics*, *clarity* and *quality* are closely related but distinct enough to have as individual dimensions, since sounds can be *pleasing*, whilst being *indistinct* and *low quality*, just as others can be *displeasing*, *distinct* and still *low quality*, although *indistinct* is usually accompanied by *low quality*. The revised method proposed above is untested and will form the basis for a more thorough analysis of the terms used to describe sounds during the interviews, as well as during the description of the perceived sounds for mapping. But in its current form it includes all four of the methods of classification suggested by Schafer (1977): acoustics, semiotics, semantics and aesthetics.

Application of Modified Macaulay and Crerar Method

The sounds listed by the participants were classified immediately after the interviews by the interviewees with the first author using the Modified Macaulay and Crerar model (see Table 1). This was completed verbally, with the participant speaking aloud and the interviewer transcribing in real time. The list was then read back to the participant who classified each sound individually. Transcription accuracy was confirmed through later comparison with the audio recordings.

A soundscape map was created for each participant based on the visualization included above. Then responses were grouped together for a typical office, this allowed the collapse of similar responses in order to create a single list of sound events, which was applied to three different sets of data. The first was the *single occupancy* responses, second *multiple occupancy* and finally *typical*.

Participants	Events	Rank	Respondents	Rank
Shared Occupants	62%	1	61%	1
Single Occupants	38%	2	39%	2
Sound Type				
Other known	85%	1	100%	1
Speech	11%	2	44%	2
Other unknown	4%	3	22%	3
Music	0%		0%	
Information Category				
Hidden	62%	1	94%	1
Visible	23%	2	89%	2
Imagined	5%	3	44%	3
Patterns	3%	4	28%	4
Time	3%	4	28%	4
Emotions	3%	4	22%	6
Position	2%	7	11%	7
Acoustical Information				
Background	63%	1	100%	1
Contextual	20%	2	72%	2
Foreground	16%	3	67%	3
Multiple Classifications				
Double	22%		61%	
Triple	4%		17%	
Quadruple	1%		6%	

Table 3: Summary of individual classifications

Table 3 shows a summary of the classifications applied during the mapping process. Within *Sound type* the majority of the responses were related to *other known* (85%) by all of the participants. Only eight of the participants referred to speech, which represented 11% of the overall events. There were seven unknowns out of 156 unique events which all referred to exterior sounds where the sources were not visible but an estimation was made such as ‘suggestion of water outside, things passing through a puddle’. There were no instances of *music*.

With regards to the *Information category* 62% of the events fell within *hidden* with only 23% being *visible*. This meant that 85% of the responses were classified according to their visibility rather than the nature of their information content. The *visible* responses generally referred to events which occurred inside the office such as ‘squeak of seat as I lean back’. *Hidden* applied to the majority of the events that occurred outside of the office, such as ‘somebody banged a door next door’. *Imagined* again referred to unseen exterior auditory events, such as ‘vans loading and unloading outside’. *Patterns* included ‘speech’ as well as ‘activity on the pavement’ all of which were relatively simple sound sources. *Time* was represented through non-work-related exterior sounds which reminded participants about the outside world, as in the case of ‘low background noise of plants, trees and wind.’ The sound of ‘traffic outside the window’ was also used to subconsciously monitor the time of day as the increased levels reminded one respondent that it was time to go home. Eight of the nine instances of *emotions* were related to people such as ‘GR clicking on keyboard’, a surprising reference was made to a ‘hard drive’ although this was due to the operator’s erratic use of the relevant computer. *Position* was used when inhabitants were made aware of the spatial dimensions of their auditory environment by a sound, an example of which was a ‘door closing in the distance’.

Sixty-three percent of the *acoustical information* was classified as *background* compared to 20% for *contextual* and surprisingly only 16% as *foreground*. Only 12% of the participants had any *foreground* sounds whereas all of the participants experienced *background* information. *Foreground* events were typically the ‘telephone’ and ‘conversations’ which the interviewee took active part in. *Contextual* mainly consisted of the ‘people’ and ‘doors’. ‘Computers’ and ‘traffic’ along with the majority of sound events were classified as *background*.

Twenty-six percent of the responses were multiple classifications, which were detailed by 8 of the 18 participants. Only two of the double classifications involved the *sound type* and they were both *speech* and *other known,* where the sound of someone talking had been combined with the other sounds which they were making at the time. Of the 24 multiple classifications of *information category* all except one involved the visibility (*hidden* or *visible*) in combination with another choice such as *emotion* or *passing of time*, this confirmed the bias on the visual nature of the classification. *Acoustical information* double classifications were more evenly spread, with every combination being present with the majority being either *foreground/background* or *contextual/background*. These represented sounds that caught the listener’s attention for a short while and then were ignored, moving from the *foreground* or *contextual* to the *background*.

Combined results for different levels of occupancy

The first stage was to clarify whether the sound description referred to a sound generated by the participant, or was within the office or exterior to it. Once this was completed, the results were collapsed to take the number of sound events down from 156 to 49 which represented a reduction of 69% (see Table 4). Record was kept of the number of participants who had contributed to each classification within each group, and each classification was calculated individually for each group. The majority was used to classify all values with equal values retaining both classifications. Figures 2 and 3 show the results from the three types of offices, with Table 5 providing the shared key.

	Single Occupancy	Shared Occupancy	Combined	Single Occupancy	Shared Occupancy	Combined
Participants	7	11	18	39%	61%	100%
Sound Events	28	37	49	57%	76%	100%
Double Classifications	7	5	8	25%	14%	16%
Location						
Participant	4	5	6	14%	14%	12%
Interior	10	22	25	36%	59%	51%
Exterior	14	10	18	50%	27%	37%
Sound Type						
Music	0	0	0	0%	0%	0%
Speech	2	3	3	7%	8%	6%
Other known	26	34	46	93%	92%	94%
Other unknown	0	0	0	0%	0%	0%
Information Category						
Visible	13	19	26	46%	51%	53%
Hidden	14	18	24	50%	49%	49%
Imagined	1	1	1	4%	3%	2%
Pattern	0	1	1	0%	3%	2%
Time	1	1	1	4%	3%	2%
Emotion	3	1	2	11%	3%	4%
Position	2	0	2	7%	0%	4%
Acoustical Information						
Foreground	8	7	11	29%	19%	22%
Contextual	3	9	9	11%	24%	18%
Background	19	22	30	68%	59%	61%

Table 4: Summary of sound classifications by type of environment.

In a comparison of the initial with the collapsed results, only *other unknown* was no longer represented, reducing from 4% to 0% of the overall responses, otherwise the method of collapsing did compare favourably to the original results. There were four notable exceptions: within *sound type*: *other known* grew from 85% to 94%, whereas *speech* fell from 11% to 6%. *Visible* and *hidden* in the information category, also changed from 23% to 53% and 62% to 49% respectively. The *acoustical information* remained very similar and the amount of multiple classifications was actually reduced from 26% to 16% of the overall results.

The *single occupancy* offices experienced 57% of the total classified sound events, compared to 76% within the *shared* offices. There was also an increased number of multiple classifications 25% compared to 14%. The figures for the single occupancy office are indicative of a space where the inhabitant had greater control over the auditory environment, making the classification more prone to unique selections. In comparison the results for the shared office recorded a greater number of events almost entirely due to the increase in the number of inhabitants.

In the *location* category the participants identified a similar number of sounds, 14% in each case, showing that the environment did not have an impact on the participants' awareness of their own contribution to the soundscape. As would be expected from a shared environment, there was a greater percentage of *interior* events, 59% compared to 36%, there was also a lesser amount of *exterior* sounds (27%) than reported by the single occupancy participants (50%).

A	Participant Stomach rumbling	R	Inhabitants' Speech	AH	Doors opening and closing
B	Participant Breathing	S	Inhabitants' Sniffing	AI	Movement of People
C	Participant Talking	T	Clock Ticking	AJ	Indiscriminant Sounds
D	Participant's rustle of clothing	U	Air conditioning	AK	People Talking
E	Participant's Feet on carpet	V	Drawers opening	AL	Telephone Ringing
F	Participant's Tinnitus	W	Pen writing	AM	Photocopier
G	Computer fan	X	Paper Rustling	AN	Knocking on door
H	Computer Drives	Y	Stapling	AO	Birds
I	Computer Screen	Z	Lunch box opening	AP	Wind
J	Keyboard Typing	AA	Door opening & closing	AQ	Rain
K	Mouse Clicking	AB	Electrical Hum	AR	Window tapping
L	Computer Alert	AC	Curtains	AS	Drilling
M	Printer	AD	Radiator Water Flow	AT	Hand dryer
N	Telephone Ringing	AE	Fluorescent lights' hum	AU	Keyboard Typing
O	Telephone Click	AF	Traffic	AV	Fire alarm
P	Table Creaking	AG	Aeroplane Flying	AW	Central Heating System
Q	Chair movement				

Table 5: Key for Figures 2 and 3

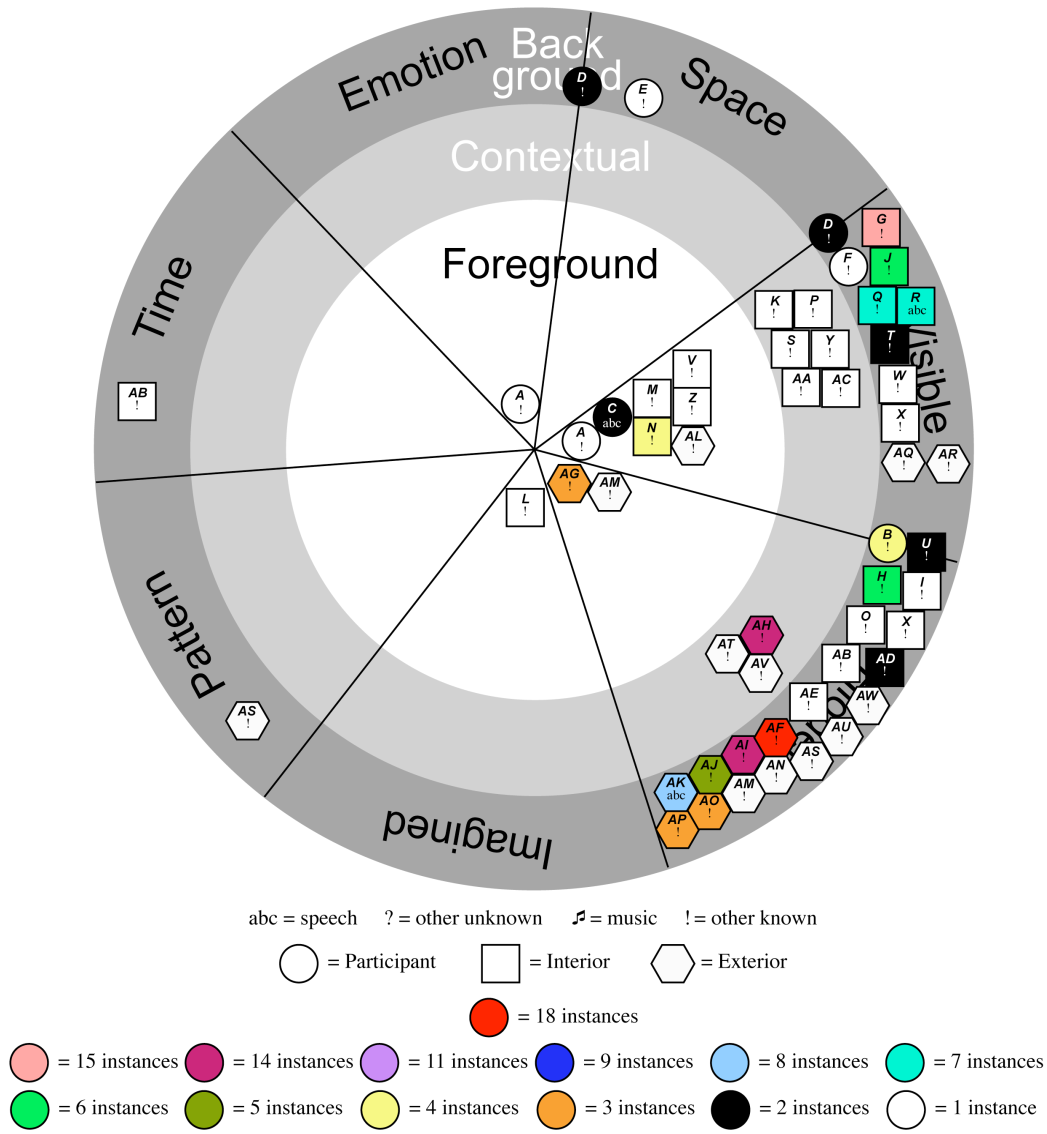

Figure 2. Pictorial Representation of Typical Office Soundscape.

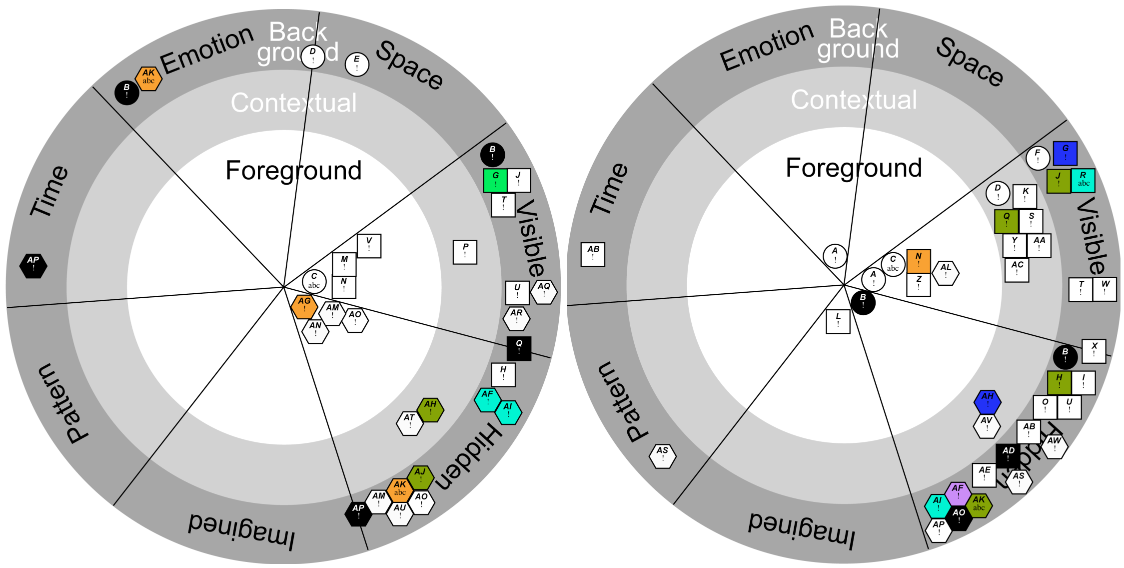

Figure 3. Pictorial Representation of Single and Shared Occupancy Office Soundscapes.

The *sound type* was almost identical for each type of office, with only a single percentage difference between the two. The *information categories* were also similar, with slightly fewer *emotions* and no *positions* in the shared office and slightly greater *visible* events, 51% compared to 46%. The main differences can be seen in the *acoustical information*; the single occupancy offices had a greater percentage of foreground and background sound events in comparison with the shared offices, which had a greater percentage of contextual sounds. This is almost certainly due to having more control over the environment and being able to hear more beyond the doors and windows because of the quieter interior.

Conclusions

Macaulay and Crerar's mapping tool proved very easy to use, with the combination of categories covering every perceived sound event. Participants uniformly found it useful as a starting point for analyzing their auditory environment.

A number of omissions became evident through the study, which could be split evenly between quantitative and qualitative. The quantitative dimensions, which are regularly manipulated during the design process, were completely missing from the modified method, these included dynamics, quantity, spatial, spectral and temporal dimensions. These could be recorded by technical means or elicited from inhabitants' responses. Any attempt to formalise into categories *onomatopoeia* should be discouraged, as a simple comparison with published lists such as Peterson *et al*. (1972) in order to aid the 'conveying of information' shows a very low level of positive correlation. There was also no indication of what the type of interaction was, whether it was produced by air passing through an object or an impact, this was partially achieved through detailing the event, but not fully, as the requirement is to represent the sounds which were perceived, rather than just a list of objects and actions. Gaver's classification of interacting materials, by the focusing on the simple sonic events would rectify this omission (Gaver, 1993).

A qualitative understanding of the sound's information content would allow an insight as to how the sound event was interpreted by the participant, such as defined by Delage (1998), whether it was an error alert, or confirmatory sound, or even unwanted noise. Further detail about a sound's perceived aesthetics would communicate to designers the listener's preferences such as included in Gabrielsson and Sjorgen's method (1979). The method currently has a visual bias in the *information category* with almost all of the sounds being categorised according to whether they were *visible* or *hidden*. This has reduced dramatically the potential to gather data about what information the sound event provides to the listener, and contradicts the nature of listening where the listener is at the centre of the soundscape rather than 'looking in' (Schafer, 1993). This could be alleviated without losing the information about the source's visibility by moving it to a separate category or encouraging participants to choose more than one category. However the current bias might accurately represent the nature of listening in that once a source has been identified, it can be ignored without further interpretation.

The modified Macaulay/Crerar method clearly showed the relative percentages of type, category and acoustical content, but was poor at representing the original sound event. It was also apparent that obvious sounds predominated; *foreground* and *contextual* sounds were notated first, whereas *background* sounds were notated last. This conforms to the way individuals interpret the world around them, but it does allow omissions due to perceptual masking, where a sound event is being established for notation and a quieter less intrusive sound is ignored, only to be notated if it is repeated after the predominant sounds have been captured. Recording the session and notating the complete set of events from the recording would alleviate this problem.

As with the previous trial prior to modification (McGregor *et al.*, 2006), the application of acoustical information did not match with the original aims of the Macaulay and Crerar paper (1998), in that this information was intended to illustrate the richness of the information being gathered. The results more closely represent levels of listening as suggested by Amphoux (Cresson/IREC,1997), where *foreground* sounds were actively monitored and interpreted (sonic symbols), *contextual* sounds told the participants about the place they were inhabiting (sonic ambience) and *background* applied to sounds that were not actively paid attention to.

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Biographies

Iain McGregor is a lecturer in Digital Media, and is studying for a PhD in Soundscape Mapping under the supervision of Alison Crerar and David Benyon. His research is based upon the reification of auditory environment inhabitants' unique soundscapes.

Dr Alison Crerar has an academic background in music, software engineering and cognitive neuropsychology. Her research interests have concentrated on software design for cognitive assessment and rehabilitation and on the use of multimodal interaction for users with sensory impairment. She is a consultant in usability evaluation.

Dr David Benyon is Professor of Human-Computer Systems, his research focus is on 'navigation of information space', a new view of HCI that focuses on how people find their way around the information spaces created by new media. He has also published on semiotics and new media, and on applying experientialism to new media. His latest book *Designing with Blends* is due to be published by MIT press in 2006.

Dr Grégory Leplâtre is a lecturer in Computing Science. He completed his PhD at Glasgow University investigating the use of non-speech sounds to support menu navigation in mobile devices. His current research interests pertain to various aspects of auditory interface design.