

Sonic Interventions: Understanding and Extending the Domestic Soundscape

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ABSTRACT

This paper presents a new study of the role, importance and meaning of sound in the home. Drawing on interview data and sound recordings gathered from seven households, this study offers fresh insight into the ways in which the *domestic soundscape* is managed and understood. The data revealed that household members engaged in a wide variety of sound management practices to monitor and control the real-time flow of sonic information throughout the home. They also showed that families were sometimes surprised and delighted by the ability to record fragments of the soundscape for later use. These findings suggest a number of roles for technology in enhancing the domestic soundscape and its associated behaviors, which we present here in the form of example *sonic interventions* created in a design workshop at the end of the project.

Author keywords

Soundscape, audio, sound tour, ethnography

ACM classification keywords

H5.m. Information interfaces and presentation (e.g., HCI):
Miscellaneous.

INTRODUCTION

Research in human computer interaction has tended both to track technological changes and to generate them, based on new understandings of human behavior with technology. This is especially true of work on home computing which has moved from a focus on fully-engaged single-person interaction with the home PC (e.g. [10]), to an examination of more ambient interactions with an increasingly interactive home (e.g. [20]).

As the shape and pace of certain interactions with technology in the home has changed, the importance of

non-visual interfaces and information has increased. This has led in particular to a number of innovations and explorations of novel audio systems and interactions including ad hoc intercom channels [17], remote audio-media spaces [12, 22], local digital music distribution [23], ambient sonic displays [5] and sonic decoration [16]. While each of these studies tell us something about the use of sound in different application contexts, they overlook the role of sound in domestic life and the way it is processed and controlled in a family context. Such information would be useful for the design of new audio systems for different applications, but also for a deeper understanding of everyday listening practices and their possible exploitation in ambient interactions with technology.

The question of how sound of all kinds is managed in the home is unanswered in the broader research literature. This has tended to examine the use of specific sonic media independently, such as music, communication, ambient and radio sound, often in contexts extending beyond the home (e.g. [3, 8, 9, 24]). The psychoacoustic and soundscape literature come closest to examining everyday sounds and listening practices, but usually in urban or office contexts, and never specifically in the home [2, 7, 11, 14, 21, 25].

Hence, the overall goal of the current research is to fill this gap by studying the *domestic soundscape* as a system in its own right. Shafer [21] defines a soundscape as “any portion of the sonic environment regarded as a field for study”. Thus, we define the *domestic soundscape* as the acoustic environment of the home, comprising of all sounds occurring in the home, from noises made by the occupants, to bi-product noises and the sounds resulting from media such as CDs and TV, to external sounds. Studying the entire soundscape serves to contextualise the studies of individual sonic media mentioned above, and helps us understand how such media are managed with reference to other sound sources in an ongoing holistic experience.

In this research we aim to understand the management, value and meaning of sound in the home, and to begin re-structuring and re-populating the corresponding design space with new design concepts inspired by our findings. These aims are addressed through a study consisting of a series of home visits investigating the current domestic soundscape, and through a design workshop to generate a series of concepts for *sonic interventions* in the home. The

paper begins with a review of related work from the literature on soundscapes and studies of sonic media in the home. It then reports the methods used in the study, followed by a presentation and discussion of the findings. Finally, a number of design concepts generated from these findings are presented, and conclusions are drawn.

RELATED SOUNDSCAPE WORK

The field of soundscape studies can be traced back to the work of Schafer in the late 1960s who coined the term “soundscape” to refer to a kind of natural music of specific environments. Inspired by insights from musicians such as John Cage and Pierre Schaeffer that natural sounds could be arranged as musical compositions in so called *musique concrete*, Schafer added scientific and environmental concerns to map and preserve the best elements of natural soundscapes which were dying out with industrialization and globalization. This motivation lay behind the ‘World Soundscape Movement’ (founded 1971) an ambitious cross-cultural comparison of soundscapes of five European villages and his classic book ‘The tuning of the world’ [21].

Along with Schafer, Truax developed an interdisciplinary course in *acoustic ecology*, which incorporated concerns for human interaction with the sonic environment both to shape and interpret it [25]. This led to the establishment of the ‘World Forum for Acoustic Ecology’ in 1993, bringing together researchers from a wide variety of disciplines (including geography, audio art, music and sociology). Work in this area continues to develop new methods and vocabulary for measuring and understanding soundscapes in urban and rural environments. For example, Augoyard & Torgue [1] have produced an entire glossary and guide to different *sonic effects* in everyday listening, while Blesser and Salter [2] make the case for a more proactive *aural architecture* for shaping such effects. A collection of modern soundscape studies has been drawn together [13] to show the range of methods and findings now represented in the field. A common concern is how to elicit subjective assessments of the remembered or actual soundscape of an area, and techniques range from the use of rating scales, sound diaries, in situ interviews and sound walks.

Very little of this approach has been applied to the field of HCI, despite the importance of sound design at the interface and in new media content development. Notable exceptions include Gaver’s work on everyday listening practices [11], but this work focused on the meaning of individual sounds in an office context, rather than on the natural office soundscape as such. More recent work by Macaulay *et. al.* has begun to fill this gap, and recommend ways of mapping the workplace soundscape in design ethnographies [7, 14]. More sociological work on the management of musical soundscapes has also been carried out, but this has tended to examine music listening in personal or mobile contexts [3, 4, 18]. In the rest of this paper, we add to both the soundscape and HCI literatures by reporting the first holistic study of the domestic soundscape, using this as a

platform to present concepts for technology inspired by its findings.

METHOD

The study was based on data gathered from seven households in the South East of England between December 2006 and May 2007. Recruitment was driven by a process of purposeful sampling [19], where households were selected to represent a wide range of sonic practices and experiences. We selected households according to household composition and dwelling type, variables which the literature indicated would be fruitful areas to study [2, 24]. Table 1 details the sample composition.

The soundscape literature highlights the problem of asking participants to reflect upon aspects of their mundane sonic environment [26]. In awareness of this fact, we carefully designed our methodology, actively seeking innovative ways to encourage and enable participants to talk about aspects of their sonic environment.

Table 1: Composition of sample, by household

	Dwelling	Composition
1	Terrace/Row house	Family with young children (4 and 6)
2	Terrace/Row House	Couple (late 40s)
3	Semi-detached/Duplex house	Family with young children (3 and 5)
4	Single-detached house	Family with adult children (21, and 24)
5	Apartment	Couple (late 20s)
6	Semi-detached/Duplex house	Shared household (4 members, late 20s)
7	Single-detached house	Family with teenagers (15 y/o twins)

Home visit 1 commenced with a ‘sound tour’ of the home, a method which built upon Schafer’s ‘sound walk’ [21]. We asked at least one member of the household to take us to each room and area of the house and tell us about the sounds in those spaces. For each area, we asked participants to ‘imagine the life of this room throughout the day, and tell us what sounds you would expect to hear and which sounds you particularly like and dislike’. By concentrating on the ‘life’ of the room and its activities throughout the day, we were able to commence our discussion of sound with reference to everyday activity and ritual, rather than an abstract discussion of everyday sound. The sound tour also provided us with a contextual overview of the home, not only in terms of its architectural blueprint, but also its sonic blueprint, affording us insight into how different areas of the home were connected sonically. The second part of Home Visit 1 was dedicated to an in-depth interview with all available household members, focusing upon: the

ownership of sound in the home, the management of sound in the home, the recording of sound in the home, the communication through sound in the home and the improvement of sound in the home. These areas were pursued through a series of open ended questions, enabling us to gather fine-grained, contextually situated data.

At the close of Home Visit 1, we deployed mini voice recorders to household members, with a series of recording instructions to be fulfilled before Home Visit 2. The purpose of setting self recording exercises was twofold: firstly to gather audio data which could be used for later analysis, and, secondly, to enable participants to engage with their sonic environment in new and creative ways. Given the highly personal nature of domestic sounds, and potential observer effects, self recording as opposed to direct observation was selected as the most ethical and effective method of obtaining audio data.

Participants were asked to record a number of different sounds. For each room in their house they were asked to record a sound they liked and one they disliked. In addition, they were asked to record sounds that remind them of home, sounds they would like to keep, and their favorite sound in the house. An interview schedule based upon these data was prepared for the second home visit, during which we played the sounds back to participants and discussed their reactions to them. All interviews were transcribed and analyzed through a process of thematic coding [15] to generate a series of categories, themes and codes for study.

FINDINGS

The main findings from the study fall within four sections, each discussing a different aspect of sound in the home: the objective and subjective soundscape, the functions and meanings of sound, the socially managed soundscape and the recorded soundscape. The following sections discuss each of these categories, and provide examples to illustrate underlying concepts that were recurrent in the data. While households were selected for the purposes of comparison based on variables that might reveal differing sonic practices (household composition and dwelling type), these variables did not prove to be as significant as anticipated. Therefore, the findings focus largely on practices and phenomenon common to all households.

The objective and subjective soundscape

Here, we investigate the domestic soundscape from two related, but ultimately different perspectives: the soundscape as objective phenomenon and the soundscape as subjective perceptual construction. We begin by considering the objective soundscape.

By the term ‘domestic soundscape’ we refer to all the sounds within the domestic environment. The typology below lists all of the different sound sources identified within the study, which, at different times, make up the domestic soundscape. The findings presented in this paper

reveal how all of these aspects of the soundscape are managed, valued and understood by household members.

- Bi-product noises (electrical hum, washing machine, keys in lock, cooking)
- Media (TV, games, music)
- Verbal (talking, shouting, calling, crying)
- Non verbal (walking, jumping, knocking)
- Alarms/notification (phone, alarm-clock, buzzer, doorbell)
- Musical instruments
- Sonic ornamentation (wind chimes, water features)
- Pets
- House noises (creaking stairs)
- External sounds (traffic, passers by, birdsong etc)
- Next door noise

It is important to note that the domestic soundscape (as with any soundscape) is not a uniform or fixed phenomenon, but is instead subject to constant change or variation. Unlike physical objects, such as furnishing or architecture, sonic aspects of the home are transient and ephemeral in nature, arising and disappearing with the same temporality as passing time. The times of night where household members slept were universally ‘quiet’ times in the house; early mornings (not withstanding alarm clocks) were also quiet times, with volume levels slowly rising as people prepared to go out. Volume levels peaked when children had friends over to play, or early evening when food preparation and high media use took place; sound levels would tail off and wind down as evening wore on and bedtimes approached. For each household these patterns were subtly different.

If the soundscape is distributed temporally, it is also distributed spatially. The nature of the domestic environment is such that different areas can have quite distinct sets of sounds occurring concurrently. A teenager’s bedroom may be the site of loud music, while the kitchen is filled with the sounds of food preparation, and the study is very quiet. However, while rooms are bounded physical spaces, largely sonically configured by the activities going on within them, sounds often leak from room to room, and can be heard in physically distant parts of the home. Sonic space has the potential to transcend physical space, meaning that the sonic blueprint of a home is, in key ways, different from its physical, architectural blueprint.

Although the soundscape has an objective acoustic reality, the ways in which it is engaged with and attended to by the listener mean that, in listening, the soundscape is also a subjective perceptual construction. We now consider how and why this is so.

Psycho-acoustics has produced models of how we listen, detailing the types of acoustic information we attend to and how we filter the complexly layered sounds in our environment to make sense of our surroundings [28]. Key amongst these is the notion that we can simultaneously operate at different levels of sonic attention, allowing us to filter out useless information, backgrounding some sounds

whilst foregrounding others. This proved to be a key element of domestic listening.

A large proportion of sounds within the domestic environment were rarely, if ever, noticed on a conscious level. When listening back to everyday mundane activities which they had recorded, such as food preparation, participants often commented that there were sounds in the recording that they had not previously noticed, and had been unaware of whilst recording. The following quotation is particularly revealing:

A lot of the time you just live with sounds. I suppose more often than not I think sounds annoy you. You become aware of a sound if they're noisy rather than if they're being pleasurable. (Shelia, Household 4)

The above neatly encapsulates the articulations of many members of the sample with regard to everyday domestic listening, i.e. that everyday sounds tend only to be noticed when they became a source of annoyance; otherwise sounds were taken for granted, backgrounded and unnoticed. The issue of sonic thresholds was found to be a significant influence in this regard. Domestic sounds such as the vacuum cleaner were often mentioned as annoying sounds which, because of their loud volume, were impossible to background. It appeared that these sounds exceeded certain thresholds or resonated at certain frequencies, at or above which sounds could not be filtered out. However, it is important to note that such thresholds are neither fixed nor absolute. For example, and to take a somewhat clichéd but widely understood instance, the sound of a dripping tap will likely go undetected during the daytime, as it is buried under a wide range of other domestic sounds. However, as the evening progresses, and sound sources fall away, the sound of the dripping tap becomes relatively louder in relation to the sonic environment, and is, therefore, foregrounded. A similar phenomenon was also evident in certain points in the study. For instance, one participant stated that he did not notice the sound of his daughter's fish tank during the day, but that it became a source of disturbance to him during the night.

Certain identified listening practices involved more conscious levels of engagement with sound than the unconscious foregrounding and backgrounding considered above. A further form of sonic attention observed was that of 'monitoring', whereby certain (often background) elements of the soundscape were actively 'listened out for'. This was manifest in a number of different ways, from individuals listening out for people returning after a night out to listening for the post to arrive, but perhaps the most striking form of monitoring occurred with parents of young children. At many points, parents described how they often remained sonically alert to their children's noises, as a way to remotely monitor and stay aware of their behavior and activities. In some cases this occurred between adjoining rooms, in other instances between the floors of a house,

where the sounds of play, beds creaking and footfalls from above could be heard through the ceiling below.

Participants displayed a high degree of sophistication in their monitoring practices, using cues such as voice stress, pitch, non-verbal information (e.g. creaking floorboards) and changes in volume to determine whether their children were behaving or whether intervention was required. The following is one example of such behavior:

If Abby jumps on her bed, you can hear the springs squeaking, so I know she's doing something she shouldn't be doing [...] There's definitely a sort of a general level of noise and atmosphere of the noise that you can kind of get an idea, even if you can't necessarily hear the words, [...] you can kind of hear, gauge the atmosphere. (Alison, Household 3)

These examples of foreground listening, background listening and monitoring reveal how household members filter sonic information on both conscious and unconscious levels. Through these listening processes, the objective soundscape becomes a subjective perceptual construction: only certain parts are consciously heard, only certain parts are consciously listened out for, only certain parts have specific meanings at specific times. This latter point is developed further in the following section, where we investigate the specific meanings and functions of sound.

Meanings and Functions of Sound

The purpose of this section is to further illuminate the subjective soundscape through an investigation of how meanings emerge and coalesce around sounds in the domestic sphere. Considering how these meanings are leveraged by household members, we reflect upon the function of sound within the home, focusing specifically upon the areas of sonic notification and sonic decoration.

Certain sounds gain meaning according to what they signify. A common example of this was the sounds of cookery, which indicate that food preparation is underway. However, the specific meaning of this sound sometimes differed depending upon the individual's relationship to the sound. For example, Robert (Household 4) liked the sound of food preparation, and found that it 'kickstarts his appetite', whereas his wife, whose task it was to prepare food, disliked this sound because of the domestic labor it implied. Sounds can also signify the arrival of certain times of the day. Alison could tell what time of day it was when she heard children going to and returning from school outside her house. Similarly, Tonia could approximate what time of the morning it was when she heard the post being delivered. While certain sounds were associated with certain times, and used to gauge the progress of the day, these signifying properties of sound were also used to keep abreast of occurrences in remote locations of the house and beyond. Jake, who was retired, used the sounds of the differently pitched car engines of his family members as they left for work in the morning to ascertain who was still

in the house, stating that when hearing them he ‘knows who’s driving off and also what time it is’.

While many sounds signify events that are in progress, they also serve to herald forthcoming events. This property of sound was found to have a variety of impacts upon listeners, not only alerting individuals to a forthcoming event, but also, at times, increasing their anticipation for, and subsequent enjoyment of, that event. For example, Amanda, who recorded the sound of the coffee machine, stated that she liked this sound because, when she heard it, she knew coffee was coming. She revealed that the sound creates a sense of anticipation for the drink, which subsequently heightened her enjoyment of the drink when it arrived. The heralding properties of sounds were also used as alerts to forthcoming events. In one example, the sound of footsteps on a gravel path alerted a participant that someone was approaching the house; in another, the sound of a key in the lock joyfully heralded the return home of a loved one. In this example, the heralding properties of sounds were used as a form of sonic alert. The following example, unique within the sample, shows how heralding sounds can be used as a form of alarm clock. Here, Donna describes the manner in which her father used to wake her mother in the morning:

He used to have to get up very early to commute, and the last thing he did before he went out was to make her a cup of tea in the morning. [...] He used to gently tap the side of the cup with a spoon. Ting, ting, ting, ting. And that would wake her up and then her cup of tea would be there and he’d go to work. Every morning for how many years? (Donna, Household 1)

This example shows a very specific and subtle use of the heralding properties of sound. Donna’s father consciously used the final sonic event in the ritual of tea making (the ‘ting ting ting’ of the spoon), as an alarm to wake his wife. A number of meanings converge on the sound of the spoon tapping: it is an alarm and a herald, but also a sound which tells Donna’s mother that her husband cares for her and is thinking about her before he leaves the house for the day.

The above examples illustrate that sounds within the home have layers and levels of meaning resting upon them. These meanings are contingent upon both the contexts in which sounds are received and the personal associations with which those sounds are bound. In short, the meaning that a particular sound has to an individual will often rest upon a web of contextual and personal associations. Through this, the objective soundscape as described in the previous section becomes a meaningful sound-world in which, and through which, household members live.

As well as leveraging the meanings bound up with sounds, participants also consciously used sound as a form of sonic decoration. A diversity of practices connected with the decoration of the home through sonic means were revealed, ranging from the use of televisions, radio and music systems to create particular atmospheres, to the use of water

features and wind chimes to create desired ambiances. Television was found to be a highly used form of sonic decoration, often turned on not to be watched but primarily to be heard. This was undertaken for a number of reasons, e.g. to alleviate feelings of isolation, to help participants fall asleep, or, in one example, to provide pets with company when household members left the house.

The Socially Managed Soundscape

One distinguishing feature of the domestic soundscape, as opposed to many other types of soundscape, is the degree to which it can be managed by local participants. While an individual within a cityscape will typically have little direct control over the sounds in his or her immediate environment, households often have relatively high degrees of control over the sonic configuration of their domiciles. We observed three major aspects of sound management within the home, around which we structure the findings in this section. The first of these relates to the direct and indirect manipulation of volume; the second to the physical configuration of the home, and the third to the influence of neighboring houses.

Dynamic volume control

The management of the domestic soundscape often, but not exclusively, centered on the control or manipulation of volume levels. This was manifest in a number of different forms, from the direct control of volume through a remote control, to more subtle forms of intervention, such as the removal of competing sound sources to lower overall volume levels. The most frequently used volume control was the television remote. Whilst watching television, DVDs, or whilst gaming, this control was frequently used to micro-manage fluctuations in volume level. Such manipulations in volume were at least partially dependent on the content of the media and the social context of its consumption. During television watching, household members often used the volume control to normalize volume levels, turning louder sections down and quieter sections up. In this, household members appeared to be trying to standardize volume levels across content. Volume levels also tended to be more keenly monitored and controlled when other household members were in the same room, but performing other tasks, such as reading. A similar phenomenon was also apparent late in the evening, when an awareness of the impact of sound upon neighbors came to the fore, and volume levels were adjusted accordingly.

Remote volume control, and volume levels more generally, were also a source of conflict within the home. Whilst many reasons underpinned these conflicts, some of them at least could be traced back to the existence of different listener preferences and hearing capabilities amongst household members. To an individual with hearing loss, the volume of a television may be frustratingly quiet, whilst an individual with unimpaired hearing may find the same volume level intrusively, or painfully, loud. For example, in household two, the father’s age-related hearing loss meant

that he sometimes set the television volume louder than was comfortable for other members of the household, who would then complain and ask for it to be turned down. Household members sometimes sought to defuse these differences in listening abilities by the way they physically situated themselves in relation to a sound source. For example, one household member stated that she could ‘hear better in one ear than the other’ and would situate herself in relation to the television accordingly, turning her back ear towards a sound source she wished not to hear.

A further strategy of volume control, namely sonic de-escalation, was also observed. This strategy saw household members actively reduce volume levels by removing sound sources which were in competition with each other. Typically this led to de-escalation in overall volume levels. Robert (Household 3) explained that, when many sound sources were present, his children’s level of noise would escalate, and their behavior worsen, as they tried to compete against these other sound sources. He sought to reduce and neutralize this escalation by removing the sounds against which the children were competing (e.g. turning off the radio), resulting in sonic de-escalation. In another example of the use of sonic de-escalation to influence children’s behavior, Stan (Household 1) stated that, as the children’s bedtime approaches, sound levels are consciously reduced, and media turned off.

Door control

The use of doors emerged as a key strategy of sound management within the home. Doors were often left open to facilitate free movement of sonic information throughout the home. For example, families with young children would keep all bedroom doors open overnight in order to hear if their children were in distress. Such strategies helped to extend the degree to which parents could engage in sonic monitoring practices, as discussed earlier. Conversely, doors were often closed in order to create private sonic spaces (e.g. to take a private call) or to localize potentially disruptive sound to one area of the home (e.g. loud music or DIY). Significantly, doors also offer a smooth continuum between open and closed (e.g. ajar, half open, fully open). This affordance allowed household members to achieve continuous levels of volume control between different areas of the house. Through this, household members were able to engage in the tacit manipulation and balancing of sometimes multiple sources of sonic information.

Noisy Neighbors

While sound levels are often monitored and managed in relation to the preference of household members, or in response to domestic activities, the study also revealed that anxieties regarding how domestic sounds may be perceived in adjoining houses could also have a strong influence on domestic sound management. Unsurprisingly, the extent to which this was an issue seemed directly linked with the architectural aspects of each dwelling. For example, neither of the detached households made any complaint about noisy

neighbors, nor felt that they need unduly moderate their volume because of their neighbors. In contrast, the two households who were most aware of neighboring noises lived in an apartment and terraced house respectively. While four of the households made reference to the fact that they occasionally heard noise from their neighbors, only Household 1 found this noise to be problematic. Stan, from this household, stated that unwelcome noise from next door, which consisted of television sounds, dog barking and arguments, impacted not only on his emotional wellbeing, but also made him unwelcomely aware of the proximity of his neighbors:

Last night we were trying to get to sleep and it was noisy next-door. It’s a horrible feeling that there are people on the other side of the wall. You feel like a rabbit in a burrow. (Stan, Household 1)

While this household, at times, suffered from noisy neighbors, the situation was sometimes reversed and they found themselves causing unwelcome noise to their neighbors. In one such instance, Stan and Donna were forced to abandon a strategy of controlled crying (which they had employed to help train their children to sleep in their own beds) because of the disturbance it caused to their neighbors. In terms of the monitoring and management of volume in the evening, there appeared to be an understanding that the volume of noise should be reduced the later it becomes, out of respect for neighboring houses. The breaking of these often tacit social contracts between households is where conflict over noise would arise, as the above example illustrates. However, the extent that a particular sound will reach between adjoining households is not always easy to determine. Whereas one can simply look at a room to determine its size and extent, it is not possible to do this with sonic space. Because of this, one cannot easily determine or quantify how loud a noise will sound on the other side of a wall. In the study, this murky area of sonic negotiation was untaken through a form of sonic inter-subjectivity, where members of the household used the sounds they could hear from next door to judge how loud their own sounds would sound to their neighbors.

The recorded soundscape

Thus far, we have presented observations about the domestic soundscape, considering its role, importance and management. In this final section of findings we consider a set of insights to have emerged not from our observations of these issues, but rather from the recording exercise *itself*.

Whilst the sounds captured during the study had various roles and meanings within the domestic environment, participants, on the whole, found the captured sounds to be mundane and forgettable. This is unsurprising, given the nature of the recording instructions, which largely required participants to record typical sounds from various rooms in the house. However, participants were also asked to record sounds which reminded them of home, sounds they would like to keep and their favorite sound in the house.

Participants responded to these questions in a wide variety of creative ways and, when framed through recording and subsequent playback, these sounds became very precious to participants. This was partially evidenced by the fact that participants often asked for a copy of these sounds at the end of the study. We refer to these sounds as *sonic gems*, so called because, although they were precious, these sounds were often previously unconsidered, buried alongside or under other soundscape elements, and uncovered only through the recording and playback exercises.

During the playback of *sonic gems*, participants typically exhibited very strong emotional responses to these recordings. A particularly vivid example arose in Household 1, where Stan had recorded the sound of his two daughters sleeping. When listening back to this, both he and his wife (Donna) were deeply affected by this sound:

Stan -It makes me feel great. I suppose it's strange, kind of, because they're out there sleeping and I can't hear them or anything, but listening to that it just makes me realize that they're there, right now, breathing, alive. And, you know, they're there.

Donna - Makes me feel they're my babies to me. I think when I hear that I realize they're babies fast asleep in their room. Little babies, all nice and warm and cuddly and snoozing. Sweet. Lovely.

The sound of their children breathing was precious to Donna and Stan for a number of reasons. It evoked strong feelings, heightening awareness of their children's existence ('it makes me realize they're there, right now, breathing, alive'), and reminding them of their role as parents ('makes me feel they're my babies to me'). It also reminds them of a different time of their children's lives, taking them back to when they were babies. Associated with this, were feelings of warmth and happiness.

Another example of a sonic gem was captured by Alison (Household 3), who recorded a short clip of her children playing with friends. On rehearing this clip during home visit 2, both Alison and her husband Robert had strong, though differing, reactions to the sound. For Alison, it was a 'happy' sound she would like to keep. For Robert, however, this sound also had another set of associations, reminding him that his children were growing up, and that this was something he felt he was missing. On being asked about what the sound evoked, he replied:

How much of my children's lives I'm missing, I suppose. [...] Because I just don't hear them during the week because they're in bed by the time I get back every night

Robert and Alison's differing reactions to this sound highlight the different relationships which household members have with domestic sounds. Because Alison spends more time at home, she is familiar with the sounds of her children playing with friends, whereas Robert's work patterns mean he only sees his children at the weekend,

when they do not have friends around. As a result, the sounds of his children at play in the recording become more precious and important to Robert, as this is the only access he has to those sounds. This draws attention to the fact that amongst the myriad of mundane noises within the domestic environment, are those sounds which have some special meaning, yet are rarely recorded, and as such are 'lost'.

Each household within the study recorded at least one sonic gem. Each of these sounds related in some way to the social relationships in the home. When these sounds are not of family members, they are of things or entities which in some way represent the home. There were recordings of family pets (which could be considered as family members) of a Christmas meal (in which all had participated) and of a piano (because 'everyone had played on it at some point').

Two of the households had, in the past, experimented with recording what we have defined as sonic gems, with varying degree of success. Stan (Household 1) had attempted to record the sounds of his children using audio tape, but was so unsatisfied with the quality of the capture that he abandoned further recording attempts. However, he still expressed a desire to record the sounds of his children, stating that he quite often has conversations with them, or hears them sing, and wishes he could record it. He stated that 'It would be nice to have a little device that went click, and it starts recording.' This indicates a desire for a simple and convenient device which could be quickly used in ad hoc recording. Stan's reflections also echo comments made about the recording exercise by other members of the study, who often found that potentially memorable sonic events would occur when the recorder was turned off.

These findings tie us back to our earlier observations about sonic perception and foreground and background listening. The process of recording and reviewing elements of the soundscape allowed participants to re-engage with their sonic environments. This re-engagement in some ways served to reverse background and foreground listening, drawing attention to sounds which normally go unnoticed in the general domestic hubbub. The recording and playback exercises served to reframe certain everyday sounds in ways which added value to them. Thus, the background and often unconsidered sonic aspects of the home became foregrounded, sometimes in incredibly precious ways.

DISCUSSION

At the beginning of the study we set out to understand the role and management of sound in the home. We did this through a soundscape approach in which we used a combination of sound walk (home tour) and sound diary (self-recording) techniques to elicit interview descriptions of the objective and subjective soundscape and associated sonic behaviors. Although the home interior was a novel site for studying soundscapes, we have discovered many properties common to the exterior sonic environment and ecology. For example, we have found that the domestic soundscape is composed of complex and dynamically

changing layers of sound. These layers and rhythms were made up of natural and man-made sounds tied to patterns of daily life in the home, and carried much information about ongoing activities and forthcoming events. However, such information could be habituated to and overlooked, through listening behaviors involving selective attention and specific signal monitoring; as in all acoustic environments [27]. This meant that the subjective domestic soundscape was quite different to the objective one, and personal to each individual family member.

This personalization of a shared objective soundscape perhaps marks a departure from previous studies which have concentrated on public spaces with people passing through. The distinctive feature of a home environment, at least for the multi-person households we studied, is that listeners were more or less co-located and exposed to a shared soundscape, albeit from their own perspective. We found that the extent to which sounds travel around the home architecture affects each individual's experience of the very same sounds, and begins to influence their meanings and affordances for action. For example, the sound of children playing in another room could be unwelcome for nearby siblings or next door neighbors, but invaluable for parents in monitoring their activity remotely. The extent to which household members could communicate with or monitor each other, isolate themselves or enjoy each other's company, was directly related to the volume of different layers of sound and their travel through the home. This led to active sound management practices such as using doors as the volume controls of each room, fighting over the remote control of media devices like the television and hi-fi and the holistic manipulation of volume levels through sonic de-escalation. Key to these behaviors was something we called *sonic intersubjectivity*, because of its relationship to maintaining common ground in conversation [6]. Household members appeared to monitor not only their own perceptions and understandings of the soundscape around them, but also those of their housemates as well. This appears to be a new finding in the soundscape literature which leads us to think about the domestic soundscape as a social achievement.

A final new discovery was almost an accident of the methodology we used. When asking families to record pleasurable sounds in the home, we found that they were often delighted with the results and asked to keep copies of the recordings. These *sonic gems* were valued for their semantic association with people or events, and sometimes for their encapsulation of an ideal of family life such as raising children, or keeping a pet. This finding is consistent with the attraction of recording ambient sounds with photographs [8], but also shows that ambient domestic sounds may be attractive enough to record on their own.

These findings suggest a number of roles for technology in enhancing the domestic soundscape and its associated behaviors which are outlined below.

The possibility of **sensing and relaying sounds** beyond the natural sonic boundaries of a physical home might allow family members to re-configure the *travel* of sound in their home. This might be useful for monitoring or communication out of earshot, as in ad hoc intercom connections or remote audio spaces (e.g. [12, 17]). They might also be used to aid existing sonic decoration practices, by bringing external sounds into the home.

The possibility of **tailoring the sound levels** of audio devices in the home to the individual hearing abilities of family members, and to the social context of use, is suggested by the findings on volume control. A difficulty for families was adjusting sound levels to accommodate other co-present activities or tailoring them to the different needs and preferences of other family members. In addition, families had difficulties with judgments of sonic intersubjectivity. Technology might be able to assist people in **monitoring sound levels** and understanding how they affect others (other family members, or people in adjoining rooms/properties).

Finally, **unobtrusive sound recording** facilities might be to capture sonic gems retrospectively just after they have happened. This would support the latent desire we found to selectively capture precious audio events quickly and spontaneously as they happen. New forms of editing and playback of sonic gem clips might also be needed to allow families to combine, retrieve and listen to recordings easily.

NEW CONCEPTS

Inspired by these findings, and by the roles for sonic interventions in the home identified above, we held a design workshop at the end of the project to explore some new concepts for sonic interventions in the home. Four out of fifteen concepts generated at the workshop are described below to give a flavor of the ideas we came up with. Each concept is deliberately 'sketchy' and serves only to stimulate further research and design work. Together they show that there is an unpopulated design space of novel audio devices in the home which could help families better manage the domestic soundscape, or capture and recycle it in novel ways.

Sound window

This concept allows users to **relay sounds** from remote locations, and was inspired by the way doors were used to continuously control the volume of sound coming into a room. It uses a virtual window to relay different types of outdoor sound into the house. Opening the window wider lets more sound in (Figure 1). The sound could be amplified local noise, outdoor sound from a distant location or abstract noise representing sensed weather conditions. By allowing people to select the sound source they gain a new type of control over the soundscape of their homes.

The source of the sound might be set elsewhere, on a remote computer. This could connect to live web microphones from anywhere in the world, or to locally

placed microphones in the garden, and stream the content wirelessly to the window. Alternatively, local or remote weather sensors might provide sensory data from which abstract sounds could be generated and relayed to the window. In the case of weather, the window could have a physical dial which lets users select the kind of weather they want to listen to.

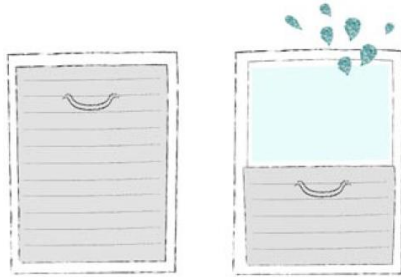


Figure 1: The Sound Window

Such a device could also be used to connect to other family members in remote locations. The live sounds of a family could be abstracted and relayed as ‘babble’ to the sound window in another home or location. The resulting composition would offer a feeling of background presence between remote family homes. Various levels of abstraction could be mutually controlled to ensure privacy or direct auditory connection, depending on the wishes and circumstances of the families involved. Hence communication would range from a kind of non-specific non-verbal hubbub to a clear open voice connection.

Appliance Cube

The study showed that sound can communicate large amounts of information quickly, heralding imminent events or signifying ongoing processes, and carrying powerful associations. A sonic notification cube (Figure 2) could be used to **sense and relay sounds** throughout the home, allowing family members to monitor remote events in the home through sound when they are beyond the range of hearing. Different appliances would be represented visually on the sides of the cube (e.g. washing machine, running bath, kettle boiling). Each appliance would be instrumented with a microphone whose output could be relayed wirelessly to the cube. The upward-facing side of the cube plays continuously. One face of the cube could be blank for silence. The other faces would effectively support the notification of events when the user is in a different part of the house or outside the home. Events not linked to appliances could be incorporated by situating microphones near sites of human activity such as the front door.

Interior sound barometer

The study indicated that people have trouble **monitoring their own sound levels**, and judging the impact of their noise on their neighbors. A visual display could show the direct decibel level of a room (or a more abstract visual representation of this) and the threshold of what can be heard through the adjacent wall, floor or ceiling. A paired

device shows similar information in an adjacent room. Both devices incorporate sound meters whose audible noise thresholds are calibrated by the occupants of each room and used to show the occupant of the house how much noise can be heard by their next door neighbors. In addition to a visual display, users could have a “self listening glass” where, instead of holding a glass to the wall to listen in on the neighbors, the glass could enable the user to hear how much of their sound can be heard in the adjoining room.

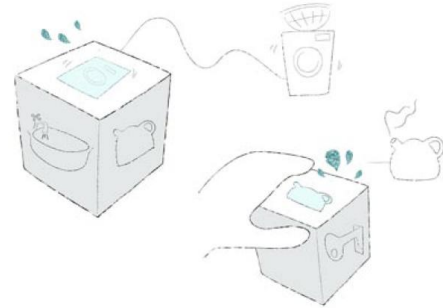


Figure 2: The Appliance Cube.

Continuous capture device and sonic gem bowl

Opportunistic and **unobtrusive sound recording** of precious domestic sounds could be supported through the use of physical sonic gems. These are small handheld objects modeled on precious stones which represent sound recordings in tangible form. Each gem has a wireless memory chip in it which interacts with a recording and playback device. A wearable recording device on a pendant or bracelet holds one gem (Figure 3). In default mode, it records and erases continuously, storing a minute of sound behind the current time on the chip in the gem. It has two buttons for retrospective and prospective sound capture. Pressing the retrospective capture button archives the last minute of recorded sound. Pressing the prospective capture button starts a new sound recording until pressed again. Once recorded, a sound can be reviewed or deleted on the pendant itself, or kept safe in the gem by removing it from the pendant. Recorded gems can be displayed in a bowl (Figure 3), which plays back the corresponding sounds as a gem is moved past a sensor. An overview of the sounds can be obtained by rummaging through the gems.



Figure 3: The Sonic Gem recorder and Sonic Gem Bowl

CONCLUSIONS

In this paper we have presented the first holistic study of the domestic soundscape. This study has begun to reveal a previously unconsidered set of behaviors and attitudes towards the domestic soundscape, spotlighting the ways in which households both interact with and interact through their everyday sonic environments. Our findings reveal that the domestic soundscape is not a single objective phenomenon but a complex subjective one which is socially negotiated between multiple inhabitants. This sets it apart from other more public soundscapes which individuals pass through but do not co-habit for long periods of time. This insight has implications for the design of audio systems and applications in the home which need to attend to the differing perspectives and hearing acuities of multiple users. Other findings begin to suggest the kind of applications that will extend the existing soundscape in attractive ways, and techniques for designing ambient interactions through sound. These relate to observed methods of sensing, monitoring, relaying, tailoring and recording sounds, and are illustrated by our 'sonic intervention' concepts. In presenting these concepts and the findings from the study, we hope to provoke discussion and inspire new ideas for the design of domestic audio technologies.

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