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Text Mining for User Perspectives on the Physical Workplace

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Abstract

This paper reports on analysis of open-ended survey responses from a commercial building indoor environment satisfaction survey database maintained by the University of California at Berkeley's Center for the Built Environment. Building from satisfaction ratings and standardised categorical responses collected in surveys for 192 U.S. office buildings, text analysis software is used to analyse text responses to open-ended survey questions, focusing on occupants' perspectives on the workplace and building overall, temperature, and acoustics. These occupant texts detail interactions between occupants and their physical environment in a technical sense but also interpret these interactions, assess their consequences, and reflect on social relationships and other matters that lie outside dimension-by-dimension assessments of the physical environment. Viewed together these texts reveal a user-centred perspective that points to issues that rest below the surface of more technical analyses of buildings, such as over air-conditioning, worker stress and frustration, workplace usability, and relationships between physical and other aspects of the workplace. Attending to this perspective could lead to improvements in occupant experience, building and technology design, building operations, and survey research, as well as inform initiatives that require occupant adaptation and cooperation, including those for greenhouse gas emissions reductions.

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Keywords

text analysis, occupant adaptation, indoor environmental quality, occupant surveys, over-cooling

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Introduction

What people do or don't do that affects the performance of the buildings they occupy has begun to take a more central stage in policy, building theory, and design. This reorientation has highlighted limitations of the existing state of knowledge on relationships between occupants and building performance. Responses to open-ended questions in occupant indoor environmental quality (IEQ) surveys can be analysed to help build beyond current knowledge limitations and to point to ways in which physical workplaces could better support those who work there. These text responses provide a richer picture of how occupants experience the physical workplace than can be obtained from the more conventional closed-ended survey questions alone. Text responses give technical detail about satisfaction ratings, but also comment on the functional importance of various IEQ problems, describe adaptation and its consequences, speak to how physical aspects of the indoor environment create workplace stress, convey emotion, and illustrate concerns that inform and lie beyond "satisfaction" with physical elements of a building. They also make it clear that building performance should be seen as more than just about energy use, productivity, or meeting satisfaction benchmarks (Leaman *et al.*, 2010).

In other words, open-ended survey responses can expand beyond the conventional framings of building environmental quality and capture more of users' multi-dimensional experiences of buildings, more of what occupants do, what they

want, and where the building in practice falls short of various theories of how it should operate and conditions it is expected to provide. This user-centred perspective can be useful to building and technology design, facilities management, the theory and practice of improving building sustainability, survey design, and even to informing the non-physical aspects of creating good workplaces. It can also be useful in devising “green” strategies that depend on actions by building occupants, in particular, buildings designed for sustainability criteria, or initiatives to reduce greenhouse gas emissions via occupant engagement (e.g., Carrico and Reamer, 2010).

This paper reports on the experimental use of text analysis software to explore open-ended survey responses from occupants in 192 U.S. office buildings for which survey results are stored at the University of California at Berkeley’s Center for the Built Environment (CBE). Since 2000, CBE’s Occupant IEQ Satisfaction Survey has collected user responses for a variety of open-ended survey questions, in addition to ordered-scale satisfaction ratings and other closed-end responses. The result is a large data base that contains IEQ satisfaction ratings linked to occupants’ own explanations for hundreds of buildings in the U.S. and elsewhere.

Using a method of extracting keywords and concepts from these open-ended survey responses, this analysis begins to place what currently exists primarily as informal or anecdotal knowledge into a more formal arena of analysis. Many of the themes identified in these texts are already familiar to those who work with

buildings in operation, for example, through stories about jury-rigs and disabled sensors, building features that occupants detest, and uneasy relationships between occupants and building management. Just as the work that goes on in buildings is not as orderly as might be assumed (Neumann, 1999; Suchman, 1983), nor are the processes that create the daily physical environment. But this kind of knowledge has only partially breached formal theory about how buildings work for their occupants, and how they might be improved. On-site interviews are the traditional method for collecting rounded information on occupant experience. Interviews potentially yield richer data than surveys, but are impractical or at least unpracticed on a large scale, are less anonymous than web surveys, and are rarely linked to satisfaction ratings, which provide a scale of reference.

Methodologically, it is straightforward to compare quantitative survey data on IEQ satisfaction from building to building. These comparisons can be very useful, but the low dimensionality of IEQ satisfaction scales misses much of the context and complexity of user experience. Better incorporating this complexity can help reorient more clinical and descriptive views of IEQ to account for users' interpretations of the environment in the context of everyday work, social relationships, adaptation, and expectations. Doing so supports Vischer's call for a user-centred theory of the built environment, one lying somewhere between environmental determinism and social constructivism (Vischer, 2008).

What occupants do

What occupants do in buildings, and when, has become of increasing interest in building research and policy. Occupants are now in focus as reasons that buildings in practice do not perform as well as designed or expected (e.g., Demanuele *et al.* 2010; Masoso and Grobler, 2010; Torcellini *et al.*, 2004), as keys to improved building energy simulation models and modelling assumptions (Clarke *et al.*, 2006; Hoes *et al.*, 2009), as agents in new technology or energy conservation schemes (Carrico and Reamer, 2010; Lomas, 2010), and as being the critical point balancing the range of indoor conditions with the diversity of occupants (Arens *et al.* 2010; Brager and deDear, 1998).

Occupants of commercial buildings adapt in various ways to the conditions they face, both physically and psychologically (Brager and deDear, 1998; Heerwagen and Diamond, 1992; Nicol and Humphreys, 1973, 2009; Nicol and Roaf, 2005). Tiwari *et al.* (2010) identify three categories of occupant adaptation to thermal conditions: physiological adjustments, psychological adjustments, and behavioural adjustments. The latter may entail personal changes such as modifying clothing, changes to the surrounding environment such as opening windows, or cultural changes such as changing activity schedules. Changes to the physical environment may be intermittent or relatively permanent. Occupant actions can affect conditions that others in the building face, whether through direct changes to the building (e.g., blocking vents) or indirectly, through how complaints filter through to actual building operation.

Proclivity to adapt to thermal conditions has been used to support adaptive comfort arguments, in particular, that buildings can and should be designed for and operated within wider ranges of temperature, more closely following outdoor weather, and that they should afford occupants opportunities to adapt. Compared to the now more conventional standards-oriented practice of trying to provide a narrower, more static range of thermal conditions, operating with a wider temperature range could save energy by reducing heating and cooling use, and do so without unduly distressing, and perhaps even pleasing, most occupants (deDear and Brager, 2001, 2002). This addresses a thermal comfort dilemma, but is only part of what the adaptation is and does.

In addition to adapting to thermal conditions, occupants adapt to acoustic, lighting, and other aspects of the indoor environment (Heerwagen and Diamond, 1992). They cope with physical and psychological discomforts faced by hanging curtains, blocking vents, listening to radios, putting up posters, leaving the office, and so on. These adjustments do not necessarily neutralize problems. They often have palpable effects on the physical and social conditions of the workplace and on how, and how much, work gets done. Adaptation and coping are normal, but they take effort, and they do not necessarily alleviate discomfort (Heerwagen and Diamond, 1992). The physical features of a workplace, and adapting to them, can create stress and reduce worker well-being and productivity (Heerwagen and Diamond, 1992; Vischer, 2007).

So beyond recognition of people's ability to adapt to environmental conditions, and the identification of barriers and opportunities to do so, a number of questions remain to be explored, particularly in regard to the institutional, physical, social, and personal dynamics that create everyday workplace environments (Brown and Walker, 2009). "Adaptation", understood in reference to occupants seeking physically comfortable conditions, is of course only a limited part of what occupants do in or to buildings.

Exactly what occupants do in any given context, why, and with what consequences is not easy to learn or predict, but there are logics to these actions and a discoverable set of patterns. Here is one way that text comments help, providing a perspective that is difficult to obtain by any other means. What patterns of actions can be identified, how are adaptations viewed by occupants, and beyond the issue of physiological comfort, how do adaptations relate to overall user experience in a building? What can be learned, for example, from the fact that a good deal of current adaptation to thermal conditions in U.S. office buildings is adaptation to over-provision of cooling and heating? The analysis below is designed to explore some of these issues by examining parts of a collection of archived open-ended survey responses as an aggregate across multiple buildings.

Open-ended text data

Surveys on indoor environmental quality are conducted with the understanding that occupant feedback lays critical groundwork for getting buildings to work

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better for their occupants (Bordass and Leaman, 2005; Zagreus *et al.*, 2004).

Beyond addressing issues in particular buildings, many studies have used multi-building databases of IEQ survey results to analyse and compare quantitative data on occupant satisfaction (Brager and Baker, 2009; Fard, 2006; Gossauer and Wagner, 2007; Huizenga *et al.*, 2006; Leaman *et al.* 1997). These analyses can reveal overall trends and patterns of building performance over building stock. These analyses suggest the possibility of an analogous examination of the textual data archived in occupant survey collections. Evidence from individual case studies is often dismissed or down-played because the context-dependence of any case makes generalisation difficult (Flyvbjerg, 2006). While context still matters, having many case studies makes it easier to allay these concerns.

Open-ended comments offered in occupant satisfaction surveys are recognized as important sources of information (e.g., Bhawani, 2010; Leaman and Bordass, 2005), and have often been used as counterpoint or illustration. In many fields, however, the research value of open-ended survey data is ambiguous, and in general such data tend to remain under-analysed or unanalysed (Geer, 1991). Text data are more difficult and time consuming to analyse than comparable amounts of numeric data; they cannot be summarized as neatly as numeric data, and they strain conventional statistical frameworks for representation and objectivity (Geer, 1991; Jackson and Trochim, 2002). Taking textual data into account also often requires a reframing of top-down perspectives: assumptions embedded in and motivating the survey instrument may not be shared by the survey

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respondent. From a research perspective, such reframing is not easy to adapt to or convey. Outside the survey realm, even product marketers have been reluctant to harvest user texts offered online, instead continuing to focus on “asking” via more closed-end surveys, rather than “listening” to volunteered opinions (Neff, 2010).

At a practical level, analysis capabilities are changing. Advances in natural language processing and text analysis software capabilities have made analysis of textual data more accessible than even ten years ago, with applications for biosciences and government intelligence dominating. Attention to text analysis for surveys has been primarily oriented toward business and market applications such as product evaluations. But survey text analysis methods can also apply to research-oriented applications, as explored here.

Survey database

Since 2000, CBE has administered an Occupant IEQ Satisfaction Survey and stored the responses. This collection now contains data for 500 buildings and 60,000 occupants, including more than 200,000 text responses. The analysis in this paper is for the subset of U.S. office buildings in that data base, and only to the 192 of these buildings for which 35% or more of occupants who were invited to participate in surveys submitted responses.¹ These buildings are not intended to be a statistically representative sample of U.S. office buildings. For example, government-owned and government-occupied buildings predominate. The buildings included cover a wide range of geography, construction characteristics,

and sizes. Year built ranges from 1917 to 2009 (median year 1984), with about 20% renovated in 2000 or later.

CBE surveys are administered over the web. Surveys include a set of core questions on occupant satisfaction with various dimensions of the indoor environment, physical workspace, and buildings, often along with additional questions on other topics such as particular building features or collaboration. At a minimum, respondents are asked to use a 7-point ordered-response scale to rate satisfaction with thermal comfort, air quality, lighting, acoustic quality, speech privacy, office furnishings, office layout, cleaning and maintenance, their workspace in general, and the building in general. When respondents express dissatisfaction with major IEQ dimensions, they are asked to provide detail by checking one or more of a series of checkbox options listing common problems (see Figures 4 and 5 below). The checkbox options in the CBE survey were developed by extensive testing and cognitive interviewing (Zagreus *et al.*, 2004), ensuring good coverage of a wide range of technical concerns.

Respondents who indicate dissatisfaction with a particular physical dimension can provide a text response giving further explanation. And all respondents, whether dissatisfied or not, are given the opportunity to provide general comments on the workplace or building. The analyses below draw on all three types of survey questions: ordered-response scale questions, checkbox questions, and open-ended text responses.

Survey respondents' comments range in length from one word to a half-page long. These responses contain a variety of type of responses: descriptions of building and workplace functioning, sometimes with technical diagnosis; personal descriptions of technical matters ("my feet are freezing"); description of personal adaptations with assessments of how well these work and constraints and dilemmas encountered; assessment of the effect of problems on producing work; more complex interpretations of interactions within the workspace and organization, both technical and social; and reflections on the survey questions, workspace design, and organizational politics.

Respondents are promised anonymity. Though the comments provided typically seem forthcoming, they also usually maintain workplace tone and discretion. These are office workers who are mostly college-educated or otherwise comfortable with words. They are often quite articulate and thoughtful about their experiences and about the social, organizational, and technical factors that shape their workplaces. Since the response rates – although normal for survey work – cover much less than all occupants, and since not all respondents answer the open-ended questions, a critic could see the collection of survey comments as a list of context-specific things that people have to say about where they work, with limited statistical properties. Instead this analysis sees the texts as a collection of expert personal assessments on how aspects of the buildings work for the people who work within them (while recognizing that self-reports are not always accurate). The fact that data for so many buildings are available means that

patterns can be identified across buildings to uncover common problems and situations. The analysis that follows is an early step in uncovering these patterns.

Text analysis method

The data analysis entailed classifying and grouping survey responses by keyword or phrases, deducing and assigning themes, generating frequencies based on these classifications, and then reading and interpreting the texts as organized by the preceding steps and identifying frequent ideas or situations contained in the text responses classified in each theme. The approach uses counts but is less statistical than interpretive and social scientific. The nuances of most situations and explanations offered by occupants can only partly be captured from keywords and statistics alone; the texts have to be read. Nor, at least in this case, is there need to be very precise with frequencies and statistical relationships, and frequency of a theme does not necessarily map to importance. Figure 1 summarizes the text analysis process.

1) Group by topic, as determined by survey question. Within each topic:2) Identify keywords and phrases, using a combination of software defaults and customized dictionaries3) Generate frequencies by keyword/phrase4) Group related words into themes of interest5) Review data within thematic groups to assess salience and identify motifs

Figure 1. Text analysis process. The analyses were conducted with SPSS Text

Analytics for Surveys (SPSS, 2005).² This software is technically capable of various relatively sophisticated natural language processing, for example, deducing (with some accuracy) sentiment such as whether a comment is negative or positive. The exploratory analysis presented here took a simple approach.³ First, the text data was organized by the basic topic of the survey question (e.g., reasons for dissatisfaction with the thermal environment). The entire comment was the unit of analysis. For each of these question-specific data sets, the software extracted keywords and phrases from the corresponding open-ended responses. This step results in frequency counts of words and phrases, with each user comment assigned to one or more keyword or phrases. An example is given below. The extraction started with a default list of keywords and phrases, which the analysts subsequently customized. This was an iterative and inspection-intensive process, especially since the data base is large. The software can recognise misspellings and typos, of which there are many in this type of data, and be trained with new words. For the question on general building and workplace satisfaction, for example, several thousand keywords and phrases were initially extracted. The software allows these extractions to be inspected in alphabetical or frequency order. Some words occurred in many comments (e.g., “building” occurred in 30% of comments), while most of these thousands of extracted keywords and phrases occurred in only one comment (e.g., “gracious”, “not buzzing”).

After inspection of the extracted keywords and phrases by frequency, analysts

developed a customized set of themes defined by grouping extracted keywords

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and phrases (e.g., “paper towel”, “faucet”, “stall partitions”, and some fifty other words or phrases go under “restrooms”). This leaves most comments as categorised into at least one, and often several, themes. Though further automated classification was technically possible, at this point it became clear that the data were complex enough that human reading and interpretation of these texts, as organized by the previous steps, was the best approach.

More detailed topics within these texts – called “motifs” here in parallel with folkloristic usage (Thompson, 1989) rather than with any precise linguistic definition – were determined by reading them, without attempting to closely track their prevalence. A motif is a distinct element of a tellable idea, such as, “vacuuming during work hours”, or “opening the window”. For example, consider the comment:

Everyone can't have a window, but on 'moderate' temperature days a window is preferred for fresh air. Weekend air temperature, movement and conditions are very poor.

This is a straightforward comment and was categorized as containing three themes, window, ventilation/air quality, and temperature. It is further identified as containing the motif, “If I had a window, this would make up for a lot”. The data are of course much richer than can be captured by simple classifications, but even this level of decomposition can be revealing.

Occupant satisfaction ratings

Figure 2 summarizes occupant satisfaction responses for the U.S. office buildings subset on basic dimensions of indoor environment, workspace, and the building overall. These ratings provide context for the survey texts analysed: from occupants' perspectives, there is lots of room for improvement. The table shows the percentages of respondents who rated themselves as dissatisfied (ordered-response scale rating -3, -2, or -1), neutral (rating 0), or satisfied (rating 1, 2, or 3). Amount of light, cleanliness of building, and office furniture comfort each satisfy about two-thirds of survey respondents, with only one in six stating dissatisfaction. In contrast, air quality, temperature, noise level, and speech privacy – factors most closely linked to building systems and basic workspace design – each satisfy less than half of surveyed occupants. Slightly more than one-third of respondents report that they are satisfied with temperature. And only one-quarter state that they are satisfied with sound and speech privacy. These are pooled satisfaction rates; some buildings within this data set satisfy even a lower percentage of occupants, and others, much higher.

How satisfied are you with?	Percentage of respondents		
	Dissatisfied	Neutral	Satisfied
Amount of Light	17	14	69
Cleanliness of Building	16	18	66
Office Furniture Comfort	18	16	66
Building Overall	16	19	65
Cleanliness of Workspace	21	18	62
Workspace Overall	21	18	61
Visual Privacy	34	14	52
Air Quality	30	24	46
Noise Level	39	18	43

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Temperature	43	20	37
Sound/Speech Privacy	63	12	25

Figure 2. Satisfaction with basic IEQ and building factors in U.S. office buildings

(28,278 respondents). The mediocre overall assessment from building occupants is echoed by findings of other many other studies (Heerwagen and Diamond, 1992; Leaman, 2009; Leaman *et al.* 2010). Not everybody agrees that occupant satisfaction is the appropriate metric for judging IEQ. Besides its innate subjectivity, Vischer (2008, p. 232) notes that: “Little effort has been expended to understand exactly what users are reporting when they rate themselves ‘satisfied’ (or not) with the built space they occupy, nor the influences of other, non-space factors on the ‘satisfaction’ that is being reported”. There is nothing inappropriate about subjectivity for assessing building performance (Leaman *et al.*, 2010), however, and it is more easily assessed than alternatives such as productivity or health (Leaman and Bordass, 2005; Vischer, 2007).

Despite the stated dissatisfaction with various components and factors of the building that seem particularly important to basic comfort and office productivity – in particular, temperature and noise – satisfaction ratings of the building and workspace overall are still over 60 percent. These overall performance ratings are thus not necessarily driven by performance ratings for the poorest performing elements, though why this is remains an open question. In any case, Figure 2 makes clear that there is much to learn about where and how theories of building and maintaining adequate workplaces fail from the perspective of occupants.

The remainder of this paper analyses open-ended survey responses for three different groups of questions: comments on the building or workplace in general; comments on the thermal environment by occupants who state that they dissatisfied with the thermal environment; and comments on the acoustic environment by occupants who state that they are dissatisfied with the acoustic environment.

Themes from the text analysis: general workplace satisfaction

As one of the final questions on the survey, all respondents are asked: “Any additional comments or recommendations about your personal workspace or building overall?” and given the opportunity to respond freely within a text box. There were 18,800 responses to this question in the U.S. office building sample, representing about two-thirds of the survey respondents for these buildings. There are three main types of answers to this question: summing up or giving overall impressions, raising issues that were not raised elsewhere in the survey or responses, and commenting further on particular issues raised earlier.

To interpret these open-ended responses as an ensemble, major themes of the responses were identified through the use of extracted keywords or short phrases (e.g., “restroom” or “too cold”), as explained above. The number of themes considered was arbitrarily set at 50. Seventy-five percent of the responses to the open-ended question on the general workplace were categorized into one of these 50 themes.⁴ Seventeen of these themes each reflected at least 5% of categorized responses, with many responses being assigned to more than one theme. These

top 17 themes, ordered in descending percentage of responses, are shown in Figure 3, along with a list of common motifs within each theme. Many of the basic IEQ concerns raised in these themes (cleanliness, temperature, air quality are among the 17) appear elsewhere on the survey, so this table is not an overall ranking of the frequency of occupant concerns. Alternative classification schemes could of course be applied.⁵

Theme	Common Motifs
1. Bathrooms	Lack of cleanliness, odor, bad manners of colleagues, distance from workspace, low-flow toilets, issues with paper products, privacy concerns, sharing bathrooms with public.
2. Cleaning	Insufficient or incomplete cleaning, disruptive cleaning during work hours, recycling issues, praise for staff.
3. Temperature	Too much air conditioning, unpredictable and varying temperatures, too little heat, too much heat, limited adaptation opportunities, inappropriate building design.
4. Air quality	Dust, fresh air, mold, drafts from and cleanliness of ventilation systems, problems with smokers and for smokers, odor.
5. Carpet, walls, furnitures	Dirty walls, dirty or old carpet, need for additional or better chairs, aesthetics and size of furniture, leaks or debris from ceilings.
6. Eating and restaurants	Lack of places in or nearby building to eat or to buy coffee, poor food selection in cafeteria or vending machines, prices, space to eat inside and outside, food odors, praise for cafeteria.
7. Parking	Hassles in finding parking, annoying allocation policies and hierarchies, expense, access to building from parking lot.
8. Acoustics	Noise distractions, speech privacy, misfit between acoustical environment and tasks, annoyance with cubicles, annoyance at design features that exacerbate noise, good and bad white noise.
9. Water	Leaks, faucets that don't stay on, water that looks or tastes bad.
10. Windows	"If I had a window, this would make up for a lot," "Since I have a window, things are much better than they would be otherwise."
11. Lighting	Insufficient light, dissatisfaction with lighting aesthetics, dislike and malfunctioning of automated lighting systems, sunlight, maintenance issues with lighting.
12. Elevators	Poor programming of elevators, noise, slowness, stairs difficult or impossible to use.
13. Doors and entries	Disruption to those nearby, entryways that don't protect occupants from weather.

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14. Building maintenance and management	Some compliments, mostly complaints that problems are not fixed or fixes are inadequate, slow response, no response, broken agreements, dilatory and avoidance tactics, differential treatment.
15. Meeting spaces	Unsuitable or insufficient meeting rooms, use of meeting rooms for individual work or conversations, poor location, lighting or thermal conditions in meeting rooms,
16. Privacy	Lack of visual and sound privacy in workspace.
17. Building security	Procedures that hinder employees such as security checks and card keys; feeling unsafe; security procedures that don't work, unprofessional security guards.

Figure 3. Top themes in user text responses to questions on general building and general workspace in U.S. office buildings.

Basic personal comforts are near the top of the list: give me a place to park, a reasonable place to eat, somewhere to buy coffee, and a clean and private place to retreat. These matters do not generally directly affect ability to perform a job – as opposed to acoustic dissatisfaction, for example. Yet these interpretations of the physical environment reflect “daily hassles” of the workplace, and are stressful to occupants (Vischer, 2007). Likely few workplaces have a forum to voice these types of concerns or a mechanism to address such problems or desires, even if they have the perception that trying to do is a valid responsibility. More design and organizational attention to these issues could reduce occupant stress, and at the same time symbolise an organization’s general attention to its employees – the latter also a potential contributor to productivity (Leaman and Bordass, 2005).

The top issue identified is “restrooms”, mentioned in 15% of categorized responses to the general workspace and general building questions. Many of the comments on restrooms might seem irrelevant, one-off, or trivial in terms of building design implications, e.g., overstuffed paper towel dispensers or floors

that reflect too much. But a restroom is a basic comfort and typically the most private place at work. It appears to be both a magnet for complaints as well as a nexus for judging the thoughtfulness of architects and designers, maintenance personnel and the organizations that employ them, and colleagues.

Beyond the themes identified in Figure 3, special building features sometimes drew comment. Particularly in new or highly renovated buildings, where occupants may have observed the design process, occupants often criticized exterior design and heavily symbolic features (e.g., atriums, grand entrances, glass buildings) that they saw as coming at the expense of functionality and occupant needs such as adequate office space, quality interiors, and general thoughtfulness about basic comforts. Call-outs on green buildings were particularly interesting, ranging from forgiveness (Leaman and Bordass, 2007) – “I’m proud to be in a green building. This isn’t diminished by the comfort issues I have” – to loathing, “The green building will survive at employees’ expense so the agency can say: We are the first with a green building, and here are the savings \$\$; screw the occupants. I am resigned to that fate and will continue to keep my mouth shut at work”.

The open-ended question on the general workplace allows occupants to frame experience on the topics covered earlier in the survey in terms of what they find most important, as well as to raise more complicated issues about the role of IEQ in their work experience. For example:

- I hate to be blunt, but this office is a bit of a dump. I appreciate the chance to take this survey and express my feelings. However, the survey seems slanted towards issues of productivity. How about a question regarding how the workplace environment affects employee satisfaction?
- Overall the physical environment is fine. The bottom line is a good manager that maintains the good attitude and motivation of the staff irrespective of the environment. The environment matters more only where the manager is lacking.
- These questions are irrelevant to me. I work for the government and have to do my work, no matter what the physical conditions.
- Many of these questions are related to things that cannot be changed without great cost. What is the intent of these questions?

These responses put IEQ in its place, tying together physical dimensions, the workplace as a social organization, and the content of the survey, with hints of resentment toward the idea that the rationale for a better physical environment is higher productivity. Interpretation of the physical goes beyond the physical, and the physical is more than IEQ. In particular, users respond not only to the physical conditions *per se*, but what can be done about them in practice, who is deemed responsible, and the organizational and social structures create the context for these physical dimensions. See below for further analysis.

Themes from text analysis: thermal environment

Figure 4 shows the top checkbox responses from survey respondents who stated dissatisfaction with the thermal environment, covering all buildings (versus just U.S. office buildings) for which the question was asked in the CBE data base.⁶

The top complaint, at 37%, is that air movement is too low. Over a third of occupants complained that their area was hotter or colder than other areas. Inaccessible thermostats and thermostats controlled by others were also very common complaints (about 30% each). Answers to the subsequent open-ended question (“Are there any other issues related to thermal comfort that are important to you?”) reflect similar concerns but convey reactions to these comfort issues, diagnoses and interpretations of their causes, description of adaptation and adjustment and barriers thereof, and a broader assessment of relationships among thermal conditions, satisfaction, social relationships, and work.

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Figure 4. Top reasons for dissatisfaction with thermal environment based on checkbox responses, over all buildings in CBE survey data base (80,918 responses over 33,436 respondents stating dissatisfaction).

Many of the open-ended responses to this survey question detail familiar adaptation and adjustment strategies: open windows, drink tea, dress in layers, walk around. Others describe the process of trying to get the facilities department to adjust how heating, cooling, or ventilation works; told here, they are rarely success stories. Respondents often deduce that nothing can, or at least will, be done, that solutions are too short-lived, or that they create new problems – a complaint about too much air conditioning may get the AC turned off completely, etc. Or they take matters into their own hands by makeshift repairs, reported with some glee, or settle on extreme adaptations (e.g., down blankets). The relationship between what the facilities department does and what occupants report to them as problems raises questions about how building systems can, do, and do not adapt to feedback from occupants and to changing conditions within buildings.

Facilities departments may often feel forced to focus on managing complaints rather than broaching longer-term improvements, while occupant responses to problems they experience as individuals can botch system design. This area deserves further study.

Respondents also commented on lack of adaptive opportunities, on top of lack of control. Certain situations seem especially frustrating to occupants because they would be easy to fix. Occupants often complain that facilities will not provide them with personal heaters or fans; rather, these must be provided by the

occupant. Worse, from the perspective of occupants, use of portable heaters and fans may be prohibited, without explanation of why. These are potential adaptations “blocked” by management. Occupants may allow for comfort problems in old buildings, especially ones with other charms, but not in cases where they perceive intentional disregard for occupants, e.g., “Why would anybody build a glass building in [a hot sunny city] without air conditioning????” Many criticized the practice of turning off air conditioning and heating at set hours (e.g., 6 pm) or on weekends, adding insult to working overtime in the name of saving money for somebody else.

The reasons for thermal discomfort also matter. Although many buildings may, in theory, be capable of maintaining temperature within a fairly restricted range, either they often do not, or these ranges do not suit surveyed occupants very consistently (Arens *et al.*, 2010). Previous analysis of the CBE survey data showed that only 11% of buildings had at least 80% of responding occupants saying that they were satisfied with temperature (Abbaszadeh *et al.*, 2006; Brager and Baker, 2009). The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 55 specifies that 80% of occupants should find thermal environmental conditions acceptable. While the terms of the ASHRAE criteria are not synonymous with satisfaction reported on a survey, the CBE survey results suggest that few buildings may meet this target.

Closed-ended survey responses on temperature dissatisfaction for the U.S. office buildings in the data base reveal as many summer complaints about being too

cold as being too hot (see also Fard, 2006; Huizenga *et al.*, 2006). That is, too much air conditioning appears to be as big a problem as too little. “Too cold” was also the most common complaint expressed in the open-ended responses on dissatisfaction with the thermal environment. This is a situation anticipated by building and office folklore, but surprisingly rarely noted in academic literature; Mui and Chan (2003), for air-conditioned Hong Kong buildings, is an exception. Many respondents comment on over-cooling as systematic wastefulness, and some describe the adaptation dilemmas that over-cooling creates, for example:

I would like more natural temperatures, without all the damn heating and air conditioning. I'd usually like it warmer, because all the air conditioning makes it too cold, but not at the expense of using the heater. Opening the window is not enough to compensate for all the air conditioning and it makes it less safe, and the window is difficult to access.

Using a heater or putting on a sweater to combat air-conditioning over which one has no control (but somebody else does) is different than the same action when it is cold outside. There were also many complaints about being too hot in the winter (38% of the winter temperature problems recorded in the survey) rather than just being too cold in the winter (69%).

Viewed in light of widespread policy interest in reducing building energy use, these patterns are remarkable: much of the thermal adaptation that is going on in buildings could be in response to systematic over-provision of cooling and

heating, rather than under-provision. But if over-conditioning is systematic, what dynamics cause the mismatch between what it is presumed that occupants want and what survey responses suggests that they would prefer? If so many people are so cold in the summer, why hasn't the air conditioning been turned down? The diversity of occupants in combination with non-uniform temperatures within the building? Traditions of building management? A function of complaint management? Poorly functioning systems and unexpected differences between the building as designed and the building as occupied? Depending on the answers to these questions, reducing air conditioning levels could save energy while improving occupant comfort and requiring *less* adaptation. But that is not necessarily easy to do; there are a host of factors that hold air conditioning into place (Chappells and Shove, 2005; Healy, 2008), including standards, design, vested interests, and the interpretation of air conditioning as prestigious.

Themes from text analysis: acoustics

Acoustic environment, including noise level and speech privacy, is among the least satisfactory dimensions of workplace IEQ (Figure 2 above). Satisfaction is lower in cubicles than in private offices (Jensen *et al.*, 2005), and green-intent buildings have been found to perform more poorly than other buildings in terms of acoustic satisfaction, in part because of the more open office environments (Fard, 2006). As far as coping with acoustic problems, respondents mention playing music, lowering voices, and taking calls elsewhere or scheduling them for times when others aren't around. But acoustic shortcomings are not very

amenable to being physically overcome by individual occupant strategies, and psychological coping is usually the main option (Heerwagen and Diamond, 1992).

Figure 5 shows the frequencies of complaints from survey respondents dissatisfied with the acoustic environment, as indicated by their checkbox responses on acoustic problems – each respondent marking, on average, three sources of dissatisfaction. Overhearing people talking is the most common response, mentioned by 61% of dissatisfied respondents. Telephones ringing and speakerphones make up 30% of the complaints. Overhearing other people’s music was another common complaint, with “music” or “radio” present in 8% of categorized comments on acoustic dissatisfaction.

Figure 5. Top reasons for dissatisfaction with the acoustic environment based on checkbox respondents, over all buildings in the CBE survey data base (121,478 responses over 43,385 respondents stating dissatisfaction).

The text responses for acoustic dissatisfaction show the same kinds of complaints, adding detail – how exactly phones are misused, etc. – and interpreting dynamics and describing coping mechanisms. The text responses also reveal a high degree of frustration, even dismay, at having to do work that requires concentration in a cubicle environment where noise is not sufficiently controlled:

- Noise is a critical issue in the building. It is so noisy I cannot concentrate. Playing music on headphones works, when I am doing work that does not require concentration but for reading and writing technical things the noise level makes it near impossible.

“Preventable” noise brought the strongest reactions, especially loud colleagues, non-work conversations and conversations that could be moved elsewhere, other people’s music, and vacuuming during work hours. Some of these might be managed by organizational strategies, including employee education or changing phone options, but there may rarely be processes in place to make such diagnoses or implement improvements.

Occupants often comment on discomfort with their own speech, both on others overhearing private conversations (work-related or not) and on not wanting to bother colleagues. They mention that they make efforts to keep their voices low, and that they change what they say and when, both of which entail effort.

Occupants may feel forced to deal with sensitive issues in email, changing the nature of the intended conversation, and possibly the amount of time taken to deal with it. Some with private offices mention closing the door, but also the

reverberations of closing the door on communications, relations with colleagues, and the thermal environment.

Summary of text analysis results

The data at hand cover a huge variety of individuals, jobs, social contexts, and physical contexts, which have been treated only in aggregate. Overall, results from this analysis of survey responses confirm much popular knowledge about what offices are like and what people do in and think about them. They are also exactly the issues that are easily forgotten when theorizing, or set aside as one-off or trivial. But they can also help inform design, offer some relatively easy ways to please occupants, and provide pointed critique of technologies and organizational systems that are otherwise presumed adequate or effective.

While traditional occupant satisfaction assessment tries to purify experience into physical and design components and to assess how well each component satisfies expectations or supports job functioning, users have a different view and different criteria. Their descriptions underscore the variety and scope of everyday situations and occupant adaptations that create the work environment, and of how these situations and adaptations are interpreted. User responses also draw attention to the importance of basic comforts that are not directly linked with work but rather are linked to well-being, pleasure, reduction of daily hassles, and a feeling of support from the organizations for which they work. Occupants read organizational values into physical systems and care not only about doing their work but about how they are treated. This is not to diminish the importance of the

purely physical interpretation of IEQ and the physical workspace's fit or misfit with what workers feel they need to do (Vischer, 2007) but rather to draw the lens wider with greater depth of field. This wider view is necessary because so many occupants find that their workspaces come up short.

The sections below present some insights from analysis of the user comments on workplace relationships, and on implications for “green” building initiatives that expect occupants to play a role.

Workplace conditions and worker relationships

Professionalism demands control over emotions, “subordinat[ing oneself] to the job at hand,” remaining pleasant and friendly no matter what one thinks of colleagues (Ciulla, 2000). This professionalism, along with standard hierarchical and social considerations, and low expectations that raising a problem will bring positive change, can leave occupants reluctant to confront many IEQ problems.

For example, some workers play music to cope with noise or to suit their work style, and the music in turn annoys others and limits the kind of work that can be accomplished. As noted in the Acoustics section above, overhearing other people's music was a common complaint, and while one worker writes confidently that his radio does not bother others, a neighbouring worker is furious about it. Technically this problem seems easy to rectify: get people to use headphones, etc. Similar for hallway conversations, etc. But the conflicting

perceptions noted above make clear that this is not so easy. Nor is it much under the control of workplace design or building operations.

It is clear from the interweaving of complaints and concerns in many survey text responses that complaints about physical elements of buildings are not completely separate from management or other workplace social dynamics – which is not to say, as others have also noted, that complaints about the physical environment are mostly a matter of workers who are otherwise dissatisfied (Klitzman and Stellman, 1989). Goins *et al.* (2010) suggests that the symbolic meaning of workplace organization and design are, overall, more important to worker performance than the physical attributes *per se*, and many open-ended comments seem to support that conclusion. At extremes, physical qualities may overwhelm other concerns, but, overall, comments about workplace organization and design transcend dimension-by-dimension assessment of physical qualities (Vischer, 2008).

An environmental determinist view of occupant experience sees occupant satisfaction as an outcome of the physical functioning of the environment (Vischer, 2008). An alternative view might be, “If occupants feel supported in their quest to do their work, they feel more satisfied with the physical environment” or at least feel that that problems are less important. Some of the open-ended comments offered by survey respondents suggest that occupants often read contempt and respect through the physical environment. Obviously, in the

case of office location, furniture quality, and the usual status markers, but the same may also be true for IEQ.

Where does the worker fall in the hierarchy of attention to people and things?

Adapting to a moderate range of environmental conditions may be fine, but when the reasons for the adaptation are management or design inattention, adaptation opportunities are intentionally blocked, abstract principles, or complaints about fixable problems are disregarded, it sends a clear message about the worker's importance in the system of work. Occupants make complex assessments that interpret the physical environment on larger scales – forgiving (Leaman and Bordass, 2007) old buildings for flaws, loathing architects for self-indulgence at the apparent cost of occupants, resenting green theory that trumps usability or praising it if the effort seemed sincere, understanding the limitations of government funding, and so on.

The goal of workplace design is rarely to satisfy employees. Rather, it might be to accommodate them in a way that supports their work subject to considerations of cost, organizational image, the diversity of occupants and visitors, and, as Ciulla (2000) discusses, an interest in “taming the worker”. These principles may conflict (Becker *et al.*, 1983). Whatever the merits of designing for worker collaboration, for example, the same principles may also contribute to serious noise problems, actually deter interaction (Becker *et al.*, 1983) and constitute a mode of surveillance. Open spaces and the possibility of clear lines of sight make the worker potentially visible at any moment, creating a distributed form of power

that shapes the worker's movements, as Foucault argued for the prison (Foucault, 1977).

The science or art of what makes for a good work environment is limited, design decisions are also less rational than might be casually assumed, space is often used in different ways than originally intended, and the nature of work within a building changes over time (Vischer, 2008). So, despite theoretical attention to providing specific temperature ranges, for example, the process of creating and managing workspaces is already at best only partly oriented to optimizing productivity, satisfying occupants, or meeting comfort ideals. These are the kinds of problems that occupants themselves are usually best suited to point out.

Implications for “green” initiatives that expect building occupants to play a role

Various environment- and energy-oriented initiatives now on the table – green design, zero net energy buildings, demand response tariffs for electricity, employee-centred conservation campaigns, energy use feedback – often make strong assumptions about the participation of building occupants in creating buildings that, in operation, meet various environmental ideals. People, rather than technologies *per se*, become levers in plans to reduce the environmental impact of buildings. Taking employee-centred conservation campaigns as the main example, serious evaluation of such efforts is very limited. Some studies show energy savings (Carrico and Reamer, 2010), but most published research covers results only in the short term, and generally only consider observed or

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reported changes in energy use rather than building performance or effect on occupants. While some campaigns may assess barriers to behaviour change, initiatives are often designed with limited recognition of the complexity of how occupants inhabit, assess, and modify their working environments, how buildings are operated in reality, and of the low levels of occupant satisfaction in many current workspaces and buildings.

In contrast to energy conservation in the residential sector, there is no direct financial stake in energy conservation for the individual occupants of commercial buildings. Plans for getting occupants to change their behaviour and their expectations to support various environmental ideals tend to emphasise individual effort, valour, and buy-in to specific means of achieving these ideals. Requests for occupants to act in particular ways – turn off lights, turn off computers, sort waste, open or close windows, draw the shades, give up their personal heater, and not override energy-saving defaults – constitute an additional set of daily demands. These demands are rarely directed to making buildings work better from the perspective of occupants. Rather the prescribed behaviours can come at the expense of getting things done (e.g., waiting for the computer to boot or the copy machine to warm up in the face of deadlines) or personal preferences. Occupants may often see mismatches between conservation requests and observed building operations, such as lighting controls that turn on lights that are not desired, unwanted ventilation, or, as noted above, too much air conditioning.

So interventions designed to induce behaviour change for reduced energy use or other environmental improvements need to be interpreted from a user perspective as well from a top-down perspective. Without this fuller vision, and some effort to improve the worst comfort problems, behaviour change strategies such as education, prompts, and competitions may be able to make only limited inroads.

Conclusions

Survey respondents' comments in response to open-ended questions, if heeded, can remind researchers and practitioners of some of what is routinely forgotten about building occupant experience, and provide an opportunity translate technical points of view to more user-centred ones. The key insight from this exploratory research is that open-ended responses are analysable and can help pry open flat "satisfaction" ratings (emotion, coping, real people, how things are interpreted, why it matters, what matters other than what was asked about) to more user-oriented perspectives. Rendering the contents of open-ended comments into data thus can help catalogue and highlight where theories and assumptions about how buildings work may be mistaken. There is often too much air conditioning, comfort problems can be extreme and may rarely get fixed, restrooms are more important than imagined, and so on. These realisations can benefit both theory and practice in how buildings are built and operated, and in how the occupants within these buildings are treated and engaged.

Text analysis is more time-consuming and less easy to render as acceptable evidence than comparable amounts of quantitative data. The report above

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scratches the surface. Though technical, methodological, and interpretative challenges remain, the open-ended survey response data already available can be taken further. It can, for example, be related to other survey responses, mined for reactions to particular technical features of buildings, or used for jump-starting an analysis of relationships between occupants and building management. Continued and more refined collection of open responses on occupant surveys is a potentially valuable route to helping confront the problem of designing and managing for real users in real buildings, especially as new green-intent paradigms emerge to change how things are done.

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¹ CBE traditionally uses a minimum response rate of 35% for including surveys in database benchmarking comparisons, to prevent inclusion of samples that may be very unrepresentative. The average response rate among these buildings is 49%. As in any survey where the sample is inherently non-random, representation of the population is not guaranteed and cannot be proven without probing non-respondents. A study reviewing a variety of customer satisfaction surveys, however, found no statistically significant correlation between response rate and reported satisfaction (Peterson and Wilson, 1992), nor is there such a correlation in the CBE surveys.

² There are also free tools available for text analysis such as Rapid Miner and Electronic Lexical Knowledge Base (ELKB).

³ Most opportunities to comment in the surveys analysed arise after an environmental factor has been rated negatively, so responses are already structured as to basic sentiment. This study did not fully assess how “smart” available natural language processing techniques can be for analysing occupant texts. At the least, text data management capabilities – identifying and extracting keywords, recognizing misspellings, applying custom dictionaries, the ability to display all texts with certain characteristics, and presenting frequencies and co-frequencies (counts of texts that have two or more co-occurring keywords or themes) – was very valuable, even while interpretation was based on reading.

⁴ Some of the uncategorized responses could undoubtedly fit in one or more of these 50 themes, while others might suggest new themes. Unclassified responses include no-comment statements like “none”, clarifying statements just as “I just moved into this office” or “satisfied with this building compared to typical possibilities, not in and of itself”. Most were just difficult to automatically classify, such as “love the location!” or “the geese are a problem”, or where generic words (“workspace” or “office”) were the only readily extractable terms. Though with more work these statements could be assigned to a theme, doing so seemed unlikely to add much insight, and was unnecessary given the non-statistical tactic taken.

⁵ Examples of the other 50 themes include way-finding, accessibility for disabled people, energy use, storage space, weather, child care, gyms, aesthetics and art, storage, public transportation, computers, density, and productivity. As is (and perhaps inevitably), there is a bias toward identifying issues that are easy to see in keywords, for example, the words associated with restrooms discussed below.

⁶ The question asked is “How would you best describe the sources of this discomfort?” followed by a list of options. The percentages pertain only to occupants who provided a response to the

checkbox question. CBE survey instruments often go into additional detail about temperature and thermal environment, e.g., asking whether the problem is “too hot” or “too cold” by season.

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