Probe Strategic Review 1999

Report 3: Occupant Surveys

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Summary

From 1995 to 1998, the Probe project (Post-occupancy Review Of Buildings and their Engineering) undertook and individually published surveys of sixteen recently-completed buildings (seven offices, five educational buildings, and four others), together with a range of introductory and overview reports. Probe was jointly funded by Building Services Journal (BSJ) and DETR, in two projects - Probe and Probe 2 - under DETR's Partners in Technology programme.

This report is part of the Probe Strategic Review series, a separate project to the original Probe building studies. Its purpose is to draw out more fully the implications of the Probe findings for clients, the construction industry, the professions and end users.

This paper, No 3 in a series of 5, examines findings from the occupant survey part of the Probe project. Report 1 covers the procedures used, Report 2 deals with technical and energy features, Report 4 has strategic findings, and Report 5 building descriptions. Report 5 may also be read alongside Reports 1-4.

The bulk of this paper has statistical evidence from the occupant questionnaire surveys of the 15 Probe buildings (the warehouse at Marston Book Services had a focus group interview only). In order to make these inevitably detailed results more digestible, they have been put into graphs (Figures 1-31), many of which contain benchmarks, so that the performance of individual buildings may be compared with norms, and a general picture of performance obtained.

Building which perform well tend to have:

- simple technology with minimal management dependency - usually with natural (NV) or mixed-mode (MM) ventilation; or
- complex technology with high management dependency, carried out pro-actively and with diligence - these are often deep plan forms with air conditioning (AC).

Buildings which perform less well tend to have technologies which management finds too challenging to operate properly (as we have found in some of the newer advanced natural ventilation (ANV) buildings and those with newer technologies which may not have been tested properly). The Probe studies show that this technology-management interaction is increasingly vital - and is often overlooked by designers and clients alike.

From occupants' perspectives:

- We are able to say with authority what makes occupants say they are happy, healthy, productive and comfortable. High on this list, as we know already, are occupants' perceptions of personal control and the perception of stable, comfortable conditions, especially in the summer.
- The Probe studies show that while some things are getting better for occupants (for instance, buildings appear to be healthier now than they were in the late 1980s and early 1990s) noise and glare problems are increasing in significance. Noise has serious impacts on perceptions of personal productivity, so there is still great scope for improvement here. Glare seems worse where special effort has gone in to designing for natural light! So better integration is needed for both lighting and noise.
- Speed of response is essential for occupant comfort and productivity. The best buildings invariably have this either through excellent usability or via attentive facilities management.

Chronic problems - such as noise and glare (there are many others) - are partly the result of weaknesses in the brief, and its management throughout the procurement process. Ends and means are easily confused (eg space planning criteria like higher densities are mistakenly given precedence over basic needs). There is also too much emphasis on design and workplace fashions, rather than objective feedback about performance and real requirements.

Where managed feedback is in place, occupants almost always benefit:

- because of better integration in the design and briefing processes, leading to better comfort conditions, especially in the summer; and
- in bigger, more challenging buildings, a facilities management and maintenance regime which uses managed feedback to best effect (eg with an excellent help desk).

The importance of managed feedback streams is becoming even clearer in an era where outsourcing services tends also to mean that important channels of feedback and quality control can be lost to core management.

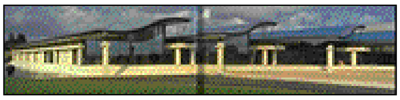
These "strategic" issues - such as ends and means, feedback and speed of response - all point to better briefing with clearer understanding of targets, more appreciation of contexts, and much more diligent monitoring of performance.

#1 TAN Tanfield House

#2 ALD 1 Aldermanbury Square

#3 C&G Cheltenham and Gloucester

#4 DMQ De Montfort Queen's Building

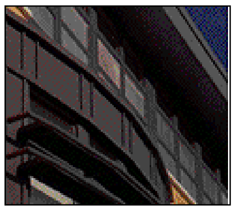


#5 C&W Cable and Wireless

Probe 1 and 2 buildings with article sequence numbers

#6 WMC Woodhouse Medical Centre

#7 HFS Homeowner's Friendly Society



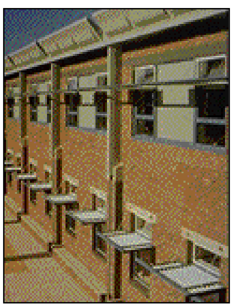
#8 APU Anglia Polytechnic University Queen's Building

#11 CAB John Cabot CTC

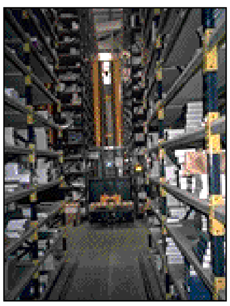
#12 RMC Rotherham Magistrates' Courts

#13 CAF Charities Aid Foundation

#14 FRY The Elizabeth Fry Building



#16 MBO Marston Books Office



#16 MBW Marston Books Warehouse

#17 CRS Co-operative Retail Society

#18 POR The Portland Building

1 Introduction

1.01 This is the second overview report covering results from occupant surveys carried out as part of the Probe series of building investigations. The first [References 1, 2] was an overview of the Probe 1 series (1995-96, 8 buildings); this one also has findings from the Probe 2 series (1997-98, 7 buildings).

1.02 Accompanying this are:

1. An overview and assessment of how the Probe investigations were carried out, with assessments of strengths and weaknesses [Reference 3]. This has a summary of the whole Probe process, with sections on the methodological framework of the occupant surveys, some details about sampling, and how the occupant surveys fit in with the whole.
2. A comparison of the main technical management and energy issues for the study buildings, with pointers to areas of success and difficulty [Reference 4].
3. A description of the study buildings [Reference 5]

Although this report may be read as a stand-alone, we recommend that it is used in conjunction with its companions.

1.03 There are also the fifteen *Building Services Journal* building articles [References 6-20] making up the majority of the Probe series or articles, each of which has a section about the individual occupant surveys with the data for that building. These, in turn, are based on the original survey reports for the buildings surveyed (which are not public domain documents).

1.04 The occupant surveys use the Building Use Studies / Probe occupant survey questionnaire, which is available for scrutiny and use under license from Building Use Studies Ltd. More details about survey methods can be found in [Reference 1].

> *Please note:*
> This paper is written for professionals with knowledge of statistical methods. Further development of the findings for a wider audience will follow.

1.05 Further statistics can be found in Figures 1-31, which form the bulk of this report.

The sample

1.06 Probe is neither a random nor representative sample of buildings: they were chosen originally for review by the editor of Building Services Journal [Reference 1]. This said, the sample is of sufficient breadth to yield a range of comparison types - not just office / non-office, but deep-plan / shallow-plan, open-plan / enclosed , and air-conditioned (AC) / mixed-mode (MM) / advanced natural ventilation (ANV) / natural ventilation (NV).

1.07 We try to assess how different the Probe buildings are as a sample from other British buildings by using the Building Use Studies UK dataset as a yardstick. Usually, the Probe sample is "better" (as defined by the various measurement scales used in the survey) than the rest of the dataset. This is what we expect because:

- buildings which are finally surveyed have already been through a sifting process involving *Building Services Journal* and the Probe team;
- managers (and, to a lesser extent, designers) who are willing to subject themselves to assessment (and have the results published, good or bad) will normally have some confidence that their buildings will survive close scrutiny.

For further details on scales and methods see *Explanatory Notes to Figures.*

1.08 By some criteria, though, Probe buildings seem close to norms. For example, studies of office occupant density consistently put British office buildings at net densities of about 16 sq m per person [eg References 21, 33]: the Probe offices come out at 17 sq m per person.

1.09 Probe buildings also show ranges of "intensities" of management input from the almost self-managing Elizabeth Fry Building (FRY) and Woodhouse Medical Centre (WMC), through to the intensively managed and maintained Tanfield House (TAN) and Co-operative Retail Services (CRS).

1.10 Success from the occupants' viewpoint often means perceived beneficial outcomes like comfort, health and perceived productivity, as well as aesthetic delight and fitness for purpose. Such variables form the bulk of the occupant study questionnaire, in addition to questions such as how quickly the buildings' system respond to users needs, and issues of importance to occupants like personal control. Again. more details about the methodology can be found in the companion paper [Reference 1].

1.11 Building occupants surveyed here are always "permanent" in the sense that they have own their desk or work area, even though they might have part-time contracts or use the building less than five days a week. So, even in buildings like the John Cabot City Technology College (CAB), Anglia Polytechnic University's Media Resources Centre (APU) and Rotherham Magistrates' Court (RMC) which have large and varied "visitor" populations, we use the permanent staff for basic comparisons. In these three cases, though, we supplemented the permanent staff sample with additional studies of school pupils, students and magistrates. As with past studies of "visitor" populations we almost invariably found that permanent staff rated the building less highly than visitors.

Use of statistics

1.12 We try to present statistics in a way which helps readers make up their own minds about what is important and significant, respecting where possible their own viewpoints and interests. This involves giving lots of facts - especially details about the contexts in which buildings are operated and used (see [Reference 5], but without swamping the reader with too much information.

1.13 Most of the analysis is underpinned with statistical tests, but these are not used too much in the report, because many people find them too academic. Where possible, data are shown in graphs.

1.14 Because of the volume of information involved, Building Use Studies has experimented with presenting them in a compact, dynamic form on the internet. The "web-enabled" version of Figure 12 allows 50 sub-graphs and pictures to be added to the basic graph, and interrogated at the user's behest. To run Figure 12, you will need an internet connection with browsers of version 4 or later.

Tactics or strategies?

1.15 This report explores the technical findings from the Probe occupant surveys with an eye to both tactics and strategy. In particular, we want to develop strategic thinking which helps with the procurement, briefing and design processes, and the relationships with the everyday use, management and maintenance of buildings throughout their working lives . After section 2, which deals with main findings, we summarise preliminary thoughts about tactics and strategies, so that these can be organised along with the technical findings into a fourth project output on strategic implications of the Probe project [Reference 21].

2 The main study variables

Overall comfort

2.01 Results for overall comfort are shown in Figures 1, 12, 13 and 26. Paragraphs 2.02-2.09 give a quick tutorial on how to read and interpret the diagrams.

2.02 Figure 1 allows comparison of individual building scores with:

1. each other,
2. the benchmark,
3. the scale midpoint.

Confidence intervals show a 95% likelihood that the true result falls within the upper and lower limits. The range of spread of the confidence intervals partly comes from sample size (normally the bigger the sample, the narrower the spread) and the responses in the survey (the more people agree, the narrower the spread).

2.03 Figure 12 has the same data as Figure 1, but without the confidence intervals. The web version of this has histograms and statistics for all buildings, plus photographs.

2.04 Figure 13 has mean scores for the buildings on each of the seven main survey variables, together with a percentile score for the building which shows where it falls in the main UK dataset

2.05 Figure 26 has percentage frequency diagrams for the Probe buildings for the overall comfort variable, showing how responses making up individual building means are distributed.

2.06 From Figure 1, it may be seen that FRY (key #15 in the top right of the diagram) scores best. This:

- has a mean score for overall comfort ranked higher than the other buildings (the scores are sorted with the highest in the top right);
- is significantly different from both the benchmark and the scale midpoint (because neither fall within the upper and lower limits).

Building #6 (HFS) is an example of one which is perceived as not significantly different from the benchmark (the benchmark mean falls within its confidence limits). Building #1 (APU) is perceived to be significantly worse than the benchmark, but still quite close to the scale midpoint.

2.07 Perceptions in buildings are significantly different from each other if a mean for one building falls outside the confidence limits for another (eg buildings #3 (ALD) and #9 (CAB) are different from each other.

2.08 In seven of the Probe buildings the occupants are significantly better more comfortable) than benchmark (#8-#15); two worse (#1-#2) and five no different (#3-#7). The UK benchmark is higher than the scale midpoint (4.22 compared with 4.0), although this has not changed with the 1999 update.

> *Please note:*
> When referring to buildings we are normally talking about occupants' perceptions of the buildings.

2.09 The percentile scores in Figure 13 show that FRY also scores the highest on the benchmark dataset (FRY %ile=99). Four Probe buildings are in the top 10 per cent (FRY, TAN, WMC and RMC). If the percentile scores for Probe and non-Probe buildings are averaged, Probe buildings come out at 57 and non-Probe 42 for overall comfort, ie Probes are considerably more comfortable.

What makes occupants rate buildings highly for overall comfort?

2.10 Occupant responses are highest when:

- absolute conditions are stable (and thus predictable), falling for the majority of time within acceptable (not necessarily ideal) comfort parameters;
    - relative conditions may be quickly changed in response to perceived circumstantial fluctuations (in eg weather, occupants' activities and colleagues' behaviour);
    - when conflicts or sub optimal conditions result, occupants can decide for themselves how to try to resolve them, rather than have outcomes foisted upon them.

2.11 The extent to which these can be achieved crucially depends on the occupying organisations' capability to manage the resulting complexity effectively and tailor performance to needs.

2.12 Features making the factors in 2.10 *easier* to achieve (they do not guarantee it) include:

- shallower plan forms;
    - cellularisation;
    - thermal mass;
- openable windows;
- non-sedentary workforce (including low VDU usage);
    - usable controls and interfaces;
    - clearly defined occupancy patterns;
    - responsive management.

2.13 Features making them *more difficult* to achieve (thus requiring greater management "intensity") include:

- deeper plan forms;
    - larger workgroups;
    - higher densities;
    - greater mixes of activities;
    - presence of complex technology, often with unwanted side effects.

2.14 Difficulties arise when organisations treat factors such as those listed in 2.12 and 2.13 independently of (ie they are not considered to have effects on) the health, comfort, productivity, utility and well-being of occupants, perhaps seeing them as ends in their own right (eg higher occupant densities) rather than means to broader ends (eg comfort).

2.15 The mix of variables at FRY (see also [Reference 5]) illustrates this particularly clearly. The features listed in 2.12 are all mostly present at FRY, and those in 2.13 mostly absent, making the likelihood high that the building will indeed be comfortable. This mix of features also helps create "virtuous" or self-reinforcing effects. For example, FRY's own non-cellular spaces also work quite well. This also applies, but to a lesser extent at RMC, for example. At FRY it was clear that the design and client team intended this, but there was also a chance element brought about by the particular mix of circumstances - the design team say that they have been trying to repeat the formula since, but have not been wholly successful.

2.16 Tanfield House (#14 in Figure 1) reinforces the point. TAN is a comfortable building because the absence of factors in 2.12 has been compensated for by diligent management of those in 2.13. TAN is also a much larger building than FRY, much more complicated and riskier, in the sense that many more things can potentially go wrong.

Summer temperature

2.17 Figure 2 shows results for summer temperature. Seven of the 15 Probe buildings have mean scores above the scale midpoint (Figure 12, columns 1 and 2). Five are above benchmark (HFS, TAN, C&G, RMC, FRY), four below (C&W, CAB, WMC and CAF) with most of the NV buildings (and CAF) not doing very well. The benchmark mean (3.77) falls at the 48th percentile for the distribution as a whole, showing that summertime conditions in British buildings are often poor, or as is the case for the staff at C&W, very poor. Again, FRY is best, with RMC next, followed by four AC buildings (C&G,TAN, HFS and ALD) with APU and MBO also above benchmark though not significantly so. However, unlike overall comfort ,the UK benchmark is *below* the scale midpoint, so only the first four are significantly better than the scale midpoint for summertime temperature. Only at FRY and RMC do occupants think that the building is more comfortable in the summer than winter (see Figure 31).

2.18 Although FRY and RMC are best, variances are quite high - indicating some disagreement amongst respondents (as well as smaller sample sizes). Variances in the AC buildings are lower, as might be expected for summertime scores. Variances are covered further in Figure 27.

2.19 The fact that best two buildings for summertime temperature comfort are both mixed mode and not air conditioned may come as a surprise. However, findings from real-world studies such as Rowe and colleagues [References 23] for Australia indicates that, when given the choice, occupants will usually opt for natural ventilation other than when conditions are exceptionally hot and humid, when they prefer air conditioning. These findings are also corroborated from other standpoints by Humphreys and Nichol [Reference 24], Oseland and Aizlewood [Reference 25] and Baker [Reference 26].

2.20 Figure 18 has further information for summer temperature conditions in the columns headed TSStable and TSHot. For TSStable, lower scores and percentiles indicate conditions perceived as stable, and higher scores/percentiles as more varied. The supplementary analysis at the foot of Figure 18 shows that although comfort appears to decline as conditions are perceived as more varied, and improves with perception of cooler summer conditions, neither scatter is significant across the BUS 1999 dataset as a whole. Note that both C&W and FRY are perceived as extremely stable in summer, but they are at the extremes of the comfort spectrum! Perceptions of variability may also be related to airtightness, but this has not been tested here.

Winter temperature

2.21 NV and MM buildings tend to have better wintertime temperatures. Figure 3 has perceptions of winter temperature. Note that:

- the range of means is much less in winter than summer;
    - variances seem to be higher than summer, especially for buildings above the benchmark;

- the least comfortable building (DMQ) is still not significantly different from the scale mid-point (see supplementary analysis table at foot of Figure 3);
- the ranked order of buildings is considerably different from summer;
- naturally ventilated buildings are better in winter.

2.22 Figure 18 shows winter data in the columns TWStable and TWHot. Perceptions of stability tend to go with comfort (eg FRY, C&G and TAN) and perceptions of coldness in winter are not necessarily a downside - people may feel healthier and be more alert. For winter temperature there is no difference between the Probe and non-Probe buildings, although the Probe buildings are much more stable in winter.

Summer and winter air quality

2.23 There is seemingly good air quality generally. These distributions (Figures 4 and 5) are significantly associated (r=0.60, p=0.0001) so they are treated together here. We do not know whether people cannot distinguish air quality differences between winter and summer, or whether there are no real seasonal differences to detect. Perceptions of stuffiness and poor perceived air quality are significantly associated in summer (p=0.0001, r=-0.78) and winter (p=0.0001, r=-0.66) so air quality and poor or excessive ventilation probably go together.

2.24 Figure 19 has further data on air quality for still/draughty, dry/humid, fresh/stuffy and odourless/smelly for summer and winter. The Probe buildings as a whole tend to be less draughty, more humid, slightly stuffier and less smelly than the dataset. FRY is a rare case that achieves summer and winter perceptions of both freshness and lack of draughtiness (although all buildings in the dataset fall on the "still" side of the midpoint on the still/draughty scale.). Perceptions of smelliness at C&W are probably the result of the close proximity of the kitchens and restaurant with office space.

2.25 Odour variables (AirSOdur, AirWOdur) are strongly correlated (r=0.94) so it may be worth dropping the winter/summer comparison for this variable. Others are less strongly correlated: AirSFresh/AirWFresh (r=0.71); AirSStill/AirWStill (r=0.43) and AirSDry/ArWDry (r=0.36) indicating summer/winter differences. *Note: seasonal comparisons for winter / spring / summer / autumn were dropped from the analysis method in 1990 because of difficulties with occupant recall and analytical complexity.*

Lighting variables

2.26 Lighting data are in Figures 6-10 and Figure 20. The supplementary graph to Figure 6 shows the scatterplot for the lighting overall variable (LtOver) with comfort overall (ComfOver). The association seems to be exaggerated by the effect of the best and worst lighting scores (which appear to be strongly associated with comfort). The rest of the distribution has the plum pudding appearance of randomness.

2.27 When this is examined more closely, the association for buildings with lighting scores less than 3.4 or greater than 4.8 (ie the outliers only) is r=0.78; the rest of the dataset with the outliers removed has an association of r=0.36. As might be expected, in perceptions of overall comfort virtuous (positive and systemic) and vicious (negative) effects may be working more at the tails of the distribution than in the body.

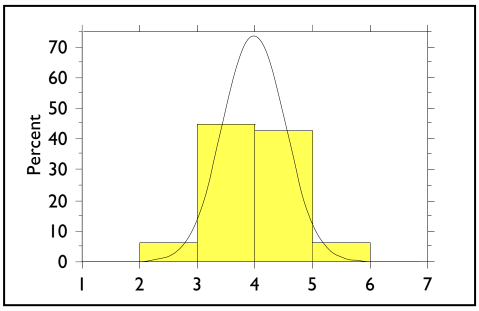
2.28 All the Probe surveys show that occupants want more natural light (see Figure 7). The scale midpoint (=4) for this distribution has a percentile score of 2, putting it at the bottom end of the distribution (ie all other buildings have a score higher than than the scale midpoint). As might be expected, buildings with deeper plan forms (C&G, HFS, ALD, CRS and CAF) are at the upper end of Figure 7, indicating perceived lack of natural light, Surprisingly, WMC is also clustered with these buildings, but this may be because doctors were forced to close their curtains to maintain privacy as their consulting rooms were overlooked..

2.29 Glare from sun and sky (Figures 8 and 20) are worst in APU (#15), C&W (#14) CAB (#13) and CAF (#12). CRS (#1) and ALD (#2) are best on absence of glare from natural sources. The three buildings scoring worst on glare are not primarily office buildings, which may help explain lack of design forethought here. It is quite common to find permanent office staff located in suboptimal "leftover" spaces, not necessarily intended for office use (eg APU). Conversely, CRS and ALD are amongst the top 10% in the overall dataset for absence of glare from sun and sky.

2.30 Occupants invariably complain of too little natural light, and tend also to say that they have too much artificial light as well! However, this inverse relationship is not as pronounced as one might think, as the supplementary scatterplot to Figure 9 shows. The association r=-0.65, which although significant is not particularly strong. Eye adaptation favours balanced light, hence perhaps the reason in Figure 9 why ANVs say that they have too little light. This may mean poorly-distributed daylight with too much contrast. This is the kind of analysis that may benefit from a finer level of resolution, looking at individual responses within particular buildings rather than averages across buildings.

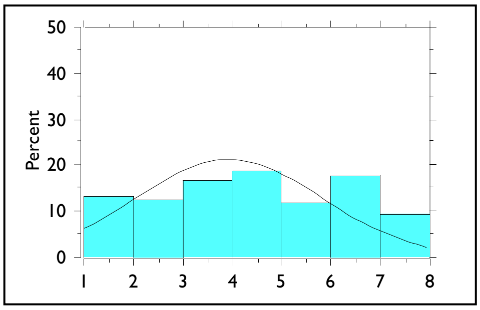
2.31 Glare from artificial lights (Figure 10) is consistently reported as worse in offices with open-plan layouts, although the uplit TAN and CRS are exceptions. TAN may be of special interest as an example of good practice, given the depth of floorplate and high numbers of relatively sedentary VDU users. Appendix 1 has more technical information on lighting. The supplementary scatterplot in Figure 10 has been included to show that increased perceptions of poor glare conditions are not significantly associated with perceptions of productivity, although a relationship in the scatter is detectable.

Distribution of noise responses for all building means in BUS dataset with normal comparison added.



Scale 1=Unsatisfactory; 7=Satisfactory

Distribution of noise responses for all individual respondents in Probe dataset with normal comparison added.



Scale 1=Unsatisfactory; 7=Satisfactory

Noise

2.32 Noise is problematical, especially in open, exposed mass situations. Figure 11, and its supplementary graphs for comfort, productivity and health, illustrate the growing significance of noise, mainly as a contributor to poor performance. The noise benchmark is almost the same as the scale midpoint, with the Probe buildings distributed around the means. Buildings with lots of unsegregated activities invariably score worse for noise (DMQ, C&W) with cellular and/or low density of occupation spaces coming out best, as might be expected (WMC. FRY, HFS). About ten per cent of buildings have really good (ie score better than 5) or bad noise (scores worse than 3) noise environments as the graph (previous page) shows for building means; the other 90 per cent have overall scores in the 3-4 range.

2.33 When we examine ratings of all individual respondents for noise for the Probe set of buildings (this page) the distribution is flat, indicating equal probabilities across the scale range (that is, about one-seventh of the respondents rate their noise environment as very poor, and so on across all seven categories on the scale).

2.34 People who perceive that noise is poor or very poor (ticking 1,2 or 3 on the scale) have an average productivity score of minus 4.0% across the Probe buildings; those with average or good noise scores have productivity scores which average plus 3.4%. The difference of just over 7% is not as great as for overall comfort scores (minus 10.7% and plus 4.5% respectively - a 15% range) but they are high enough to warrant close attention. Noise is also a contributory component of the overall comfort score.

2.35 As well as productivity and comfort, noise is also associated with health (see the Figure 11 supplementaries for building mean scores, which also have test statistics). As can be seen from the scatterplots, these variables are autocorrelated (that is, health, comfort and productivity are all associated with each other). Because of this, it is probably only of academic interest to sort out which components contribute most to the associations. From a practical standpoint, it is sufficient to know that health, comfort and productivity scores are approximate surrogates, so you can use any one of them and get broadly similar results.

Buildings overall

2.36 From the occupants' perspective which are the best buildings overall? Figure 13 (2nd column from right headed "Mean") has the average of the seven "summary" comfort variables, and a percentile based on this average (rightmost column headed "%ile"). Four of the Probe set (TAN, C&G, RMC and FRY) fall in the top ten per cent (that is, with percentile scores greater than 90; one, C&W, falls in the bottom 10 per cent. All 15 Probe buildings have a percentile average of 62; the non-Probe buildings 42, indicating that the Probe buildings overall are better for comfort.

2.37 Similarly (from Figure 16), Probe buildings score better overall on productivity (Probe average percentile 68, non-Probe 41).

Pearson's r associations between variables discussed in 2.35-2.38. Source: 25 buildings in BUS dataset

	Health	Noise	Productivity	Comfort
Health	1			
Noise	0.44	1		
Productivity	0.74	0.60	1	
Comfort	0.77	0.45	0.78	1

25 observations were used in this computation.

Do ventilation types make a difference?

2.38 The answer is almost certainly "yes" but small sample sizes increase the strictness of the statistical test, so differences do not come out as significant. Figures 13 and 14 have the details. Using average comfort criteria (the average of the seven main comfort variables), buildings of all four ventilation types appear in the top 15 per cent, and 3 out of the 4 types are in the bottom 15 per cent - the exception being MM. From Figure 15, AC scores best (mean=60.2), then MM (49.3) and NV (45.2). ANV is lowest (percentile mean=29.3). There may be a provision - alleviation- intrusive control triangle at work here, with AC better at comfort provision, AC and MM better at discomfort alleviation and ANV too intrusive, at least as currently implemented and managed, for all-round comfort.

Speed of response

2.39 As was shown in the Probe 1 study [Reference 2], occupants' perceptions of speed of response (how quickly their complaints are dealt with) are strongly and positively associated with comfort and productivity (Figure 17). The top two graphs in Figure 17 show the scatterplots for the whole dataset with the Probe buildings highlighted. The bottom graph has Probe buildings only. Here the correlation may be exaggerated by the influence of the ANV buildings which cluster towards the bottom left of the plot.

Perceived control

2.40 The importance of perceived control to building occupants is well known (eg References 28-32). A selection of the Probe data on perceived control (Figure 22) shows nothing to contradict earlier findings. The association between average control and health (the bottom supplementary graph) is particularly strong.

Control variables and their associations

Control over …	Health	Productvity	Overall comfort
Heating	0.18	0.33	0.32
Cooling	0.35	0.22	0.32
Ventilation	0.77	0.23	0.34
Lighting	0.39	0.04	0.20
Noise	0.71	0.51	0.60

Pearson's r

2.41 Breaking the health graph down into the individual contributors (see box, above) shows that control over ventilation (r=0.77) and control over noise (r=0.71) have the highest correlation coefficients, with cooling (r=0.35), lighting (r=0.39) and heating (r=0.18) all lower.

	Buildings	Individuals
Probe	0.86	0.54
Dataset	0.80	0.46 *

* This calculation is based on 20 buildings

2.42 Productivity, however, has a different pattern of association: noise (r=0.51) and heating (r=0.33) are most important here; then cooling (r=0.22) and ventilation (r=0.23). There is no significant association between overall productivity and lighting scores: (r=0.04).

2.43 Overall comfort is dominated by noise (r=0.60), but there is also an even effect amongst the others.

2.44 These data may help to explain further why perceived control is seen to be so important by building occupants, a fact which still continues to be underestimated by designers. Control over ventilation and noise seem to be most important for *health*; control over noise (again) and heating contribute most to *productivity*, and noise, plus the balance of the other factors, for *comfort*. Thus all the components of perceived control have important effects, with noise especially so.

Quickness

2.45 "Quickness" data - the perceived speed that building occupants think that needs are met - are in Figure 22. The right-hand column has an average quickness score (AvQuick) and a percentile based on it (AvQuick%ile). RMC, WMC, FRY and POR come out best - all NV or MM with openable windows. The supplementary graphs to Figure 22 have average quickness (AVQuick) plotted against Comfort (ComfOver), Health and Productivity. All show significant positive relationships (ie the better perceptions of quickness give more comfortable, healthier and more productive outcomes).

Perceived productivity and comfort

2.46 Figure 24 shows the extent to which the overall comfort and productivity variables are associated with each other. Ventilation types have also been added to these graphs. The relationship is consistently strong both for buildings and for individuals. The box (this page) shows differences between correlations calculated for buildings and for individuals. Both are significant, positive relationships but the building correlations are stronger, an effect attributable to the buildings themselves: like-minded respondents are clustered in the buildings rather than randomly distributed between them.

2.47 The scatterplot and table at the foot of Figure 24 show how the samples divide by productivity scores for comfortable and uncomfortable staff. The difference is over 12 per cent for all Probe buildings averaged together. But, as the graph shows, the difference becomes *less* pronounced as buildings become more comfortable. That is, uncomfortable staff in, for instance FRY, are less likely to say they are unproductive than uncomfortable staff in, say, APU. This is further evidence in support of the "virtuous" and "vicious" reinforcing effects reported in earlier papers (eg Reference 1).

Frequency charts for overall comfort

2.48 Figure 26 has percentage frequency diagrams for the overall comfort variable, showing the percentages of respondents who think the building is comfortable. For example, for TAN (top left in Figure 26) about 20% of staff give the building a 7 rating on the scale 1=uncomfortable; 7=comfortable.

For the sake of brevity, similar versions of Figure 26 have not been reproduced for the other survey variables. This would mean more than 30 full-page diagrams. However, this information is available in a more compact web-enabled format for 19 of the variables via www.usablebuildings.co.uk.

Variances

2.49 Most of the analysis of occupant data has used tests based on both means and variances, but data reported tends to have used only means. This is because people find it easier to follow. However, our informal analysis of the Probe data has shown that there may be benefit in studying variances in more detail. Figures 27-30 show why.

2.50 Figure 27 has scatterplots for the productivity variable (shown as the dependent variable on the y-axis) with selections of variance data (eg ComfOverVar: the variance statistic for the ComfOver variable) on the x-axis. Low variance (to the left on the scatterplot) means that respondents tend to agree about their responses (they can agree that everything is satisfactory, or agree that things are unsatisfactory); high variance (right-hand side) means they disagree. The Probe buildings are shown on these plots split by ventilation type.

2.51 The striking features from Figure 27 are:

- the strength of the relationships for ComfOverVar, AirSOverVar and AirWOverVar - the more people agree, the better the consequences for productivity;
- the clustering of the ANV buildings (green squares on the plot) where high variances may represent high context-dependency.

Given that ANV buildings may be introducing a special effect of their own, all the charts indicate that higher variance (greater disagreement) means lower productivity (the fitted line points down to the right, whether or not the relationship is strong).

2.52 This also applies in Figure 28, which has productivity plotted against lighting variables' variances. Here the effect of the artificial lighting variable LtArtVar appears particularly strong, perhaps again driven by the clustering of the ANV buildings. We have been systematically collecting variance information in the Probe occupancy dataset, and opportunities for further analysis may be possible.

2.53 Figure 29 and 30 have ComfOverVar as the independent variable with all five quickness and control variables on the dependent axes. These diagrams are more speculative and harder to interpret as plots. However, the r-squared statistics (bottom of plots) show that the noise quickness variable (from Figure 29) has the strongest association (r^2=0.55), followed by heating (r^2=0.40) and cooling (r^2=0.30). This says that the more people disagree about their comfort conditions, the more quickness of noise response is important. Again there is clustering of ANV buildings towards the right of the chart, an indication, perhaps, of the compounding effect of poorly-considered open-plan working areas.

2.54 Figure 30 has control over noise, again with the highest r-squared (=0.24), emphasising yet again the growing significance of noise.

Further statistics about occupancy and use

2.55 Figure 31, for Probe 2 buildings only, has further statistics on occupancy and use derived from the occupancy surveys. Most of this information is self-explanatory for individual buildings, but needs further development to help provide a set of robust benchmarks.

	Productivity score next to window %	Productivity score not next to window	Difference	Better or worse?
ALD	-7.9	-1.1	-6.9	Worse
TAN	5.8	8.8	-3.0	Worse
C&G	-0.5	2.1	-2.7	Worse
DMQ	-9.1	-10.7	1.6	
C&W	-4.5	-11.4	6.9	Better
HFS	1.5	3.0	-1.5	
APU	-6.7	-4.9	-1.8	
MBO	7.0	8.0	-1.0	
CAF	-3.1	-4.4	1.4	
FRY	7.6	2.2	5.4	Better
CRS	4.0	-0.6	4.6	Better
POR	9.0	-4.0	13.0	Much better
Average	0.3	-1.1	1.3	

Window seats

2.56 In general, people with window seats tend to be more comfortable (and thus more productive as comfort and productivity are associated). However, analyses on window seat effects sometimes do not throw up differences (eg. the relationship between whether or not you have a window seat and overall comfort is not significant across all *individuals* in the Probe dataset). The box above shows building averages for productivity where window differences are shown - some positive, some negative, and several with no difference. These effects do not seem to be generalisable in the way that we thought in earlier studies, so it seems that window effects are context-dependent.

2.57 For instance, window locations can be a relief from poorer conditions elsewhere (eg CRS, where staff unofficially opened windows to improve ventilation) or part of an all-round excellent, controllable environment (eg FRY) where a window location makes things even better.

2.58 We have recorded ranges of 14-76 per cent of staff with window seats in Probe buildings.

Churn

2.59 The average building churn figure (from the 1999 BUS dataset) is ~30 per cent (that is, 30 per cent of staff have worked in the building for less than one year). Similarly, the work area churn figure is ~50 per cent (50% move their work area at least once a year). Do churn rates affect comfort and productivity? Probably, but we do not have enough evidence yet to be sure. Both productivity and comfort increase as churn rates go down, but small sample sizes stop the relationships from being significant. (see rows 2 and 3 of Figure 31).

Time spent at desk and VDU

2.60 Many buildings have relatively sedentary office staff spending much of the day at their desk (all instances in Figure 31 have 90 per cent of staff spending four hours a day or more at their desks). Time spent at desk seems to be associated with comfort and productivity when conditions overall are worse, but the relationship is not consistent. Time spent at VDU was significantly negatively associated with comfort at RMC, CAF and POR, but we do not know why.

Discomfort experienced

2.61 All buildings have over 65 per cent of staff reporting discomfort of some sort with the heating, cooling, ventilation, lighting or noise (row 8 of Figure 31). RMC has an excellent score of 65. Even FRY, excellent in many respects, has 73 per cent of its staff finding something wrong.

Productivity

2.62 The best of the Probe 2 set for productivity measured by the proportions of staff rating productivity with a plus score were CAB, FRY, MBO and POR (row 15, Figure 31).

Summertime comfort

2.63 Probe 2 buildings rated more comfortable in summer than winter were RMC and FRY (row 24, Figure 31). These are rare cases in the UK dataset.

3 Strategic pointers

3.01 Given this varied dataset, supplemented by knowledge of technical performance [References 4 and 5], what pointers can be drawn, especially for future strategy? This list only explores new ideas suggested by these results, rather than repeating older findings.

3.02 *Ends and means:* From the occupants' perspective comfort, health, safety and their effectiveness at work (productivity) are usually the most important. Personal control also ranks highly because this is a means of achieving these ends, especially when conditions are poor. Occupants also seem to have a clearer understanding of what a building should be for. Designers, for example, can put means before ends (eg DMQ and C&W where green building and aesthetic priorities seemingly trump usability and occupant comfort).

3.03 *Personal control, especially noise:* Perceived control over noise seems to be more significant than before (not surprising in view of more open working layouts and the use of more wall and ceiling surfaces for heat sinks). However perceived health seems to be affected primarily by perception of ventilation and cooling control, productivity by noise and heating, and comfort by noise and a combination of heating, cooling, ventilation and lighting. This suggests that all components of perceived control are at work, except for the relationship between lighting and productivity which appears to be relatively insignificant.

3.04 *Compensation:* Good occupant performance is easiest to achieve when certain features are present (see para 2.12). When these are absent they need to be compensated for by better management and by more carefully considered designs. Two examples: where personal control is lacking management response becomes a vital factor, and layout of circulation spaces to cut out unwanted noise and distraction (eg TAN).

3.05 *Variances* show significant effects (eg the more people agree about their comfort conditions the more productive they say they are). This may be a good way of understanding the importance of stable ambient conditions exemplified by FRY.

3.06 *Context*: These findings increasingly point to the primary importance of context. Context can often over-rule generalisations (as the results on window seats show - window seats are not necessarily better). There is also the issue of *importance*. To occupants, things become important when they are either absent (eg no personal control) or not working properly (eg unstable AC).

3.07 *Defaults* are the settings which buildings and their equipment adopt under normal use. There is an increasing tendency for default (ie normal) conditions to be uncomfortable (eg often noisy or hot) with poor energy efficiency (eg lights left on unnecessarily). The obvious implication is to think harder about creating "robust" default settings which are both more comfortable and energy efficient.

3.08 *Further strategic issues:* These findings are expanded further in [Reference 22] which deals with the strategic pointers from the Probe studies on a broader canvas - including technical and energy issues as well as occupants.

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Explanatory notes to figures

Dataset
Probe buildings are benchmarked against the Building Use Studies 1999 dataset. The dataset uses fifty buildings, with the most recent buildings surveyed in the UK by Building Use Studies. The dataset is continually being updated, so published benchmarks vary as the dataset evolves.

The BUS dataset is not a random sample of buildings: this would be extremely expensive to obtain and update. The dataset may thus be biased towards the buildings that BUS has been allowed to survey, which normally means those buildings whose managers or developers are committed to qualitative improvement. This said, it does *not* mean that the buildings necessarily all perform well! As the data reported here show, the dataset seems to represent a spectrum of performance from excellent to poor.

Use of statistics
Buildings and their occupying organisations are complex human and physical systems with many variables and countless interactions. To avoid tedious repetition, questions about operating contexts and methods of analysis are often skipped for sake of brevity.

To overcome the inevitable shortcomings, we have chosen an approach which utilises familiar statistics like averages with less familiar numbers like percentiles, plus a modicum of testing using confidence intervals plotted on charts which are easy to read without a prior understanding of statistical testing.

We have tried to dealt with: *absolute comparisons* (whole dataset sample means and their variations), *relative comparisons* (how particular buildings compare with all the others in the dataset) and *benchmarking* (how buildings perform on a cluster of attributes against the whole dataset).

Confidence intervals
These are used in Figures 1-11 a) to show typical variability in the samples and b) to provide an easy way of telling whether buildings are either significantly different from each other (a mean does not overlap the sampling spread) or significantly different from the benchmark (the benchmark mean falls outside the spread).

Percentiles
Percentiles compare the percentage of data that are equal to or less than an observation and provide a helpful way of telling quickly how buildings perform with respect to each other, the scale mid-point (converted to a percentile) and the benchmark (also converted to a percentile). For example, In Figure 13,Tanfield House scores 4.57 on the 7-point scale for summer temperature which falls at the 90th percentile. This means that 90 per cent of the full dataset of 49 buildings are equal to or fall below the Tanfield House score.

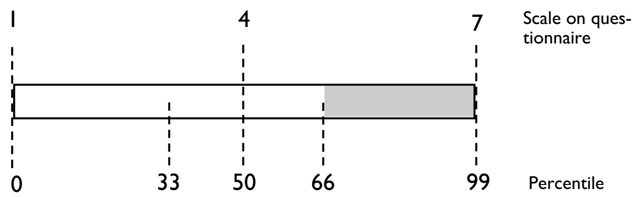
Average percentile (first occurs in Figure 13)
The "average percentile" is a measure coined here to denote a percentile calculated from the ranked averages of mean scores (NOT the average of percentiles). The average percentile allows buildings to be compared a) between themselves; b) relative to the full dataset. In Figure 13, for example, (rightmost column), Tanfield House scores 97 out of a "perfect" 100 (for the variables considered), showing a) that it is the best of the Probe buildings for these variables and b) that is in the top 10 per cent overall on all the seven comfort variables for the complete dataset of qualifying buildings.

Probe better or worse than dataset?
For the main variable types (eg Figure 13) we have calculated a "Probe average" and a "Non-Probe average" to help understand whether the Probe buildings are different from the overall dataset. For example, in Figure 13, the Probe average is 62 and the non-Probe average is 42, indicating that for these variables the Probe buildings are better (the high end of the scale is best in this instance).

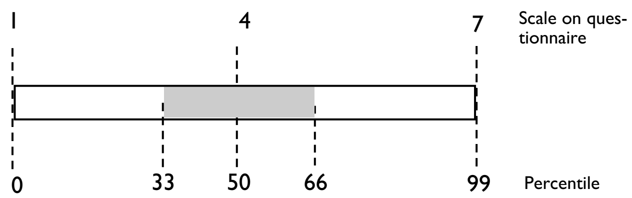
Web-enabled graphics
We are experimenting with a dynamic form of graphic which allows much more information to be presented. This is Figure 12.

Scales
Three types of scale are used in occupant questionnaires which convert when analysed into three types of percentile .

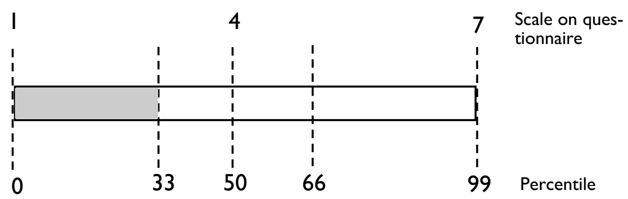
Type A:
Satisfactory, good or high towards right of scale eg ComfOver (1= Unsatisfactory; 7=Satisfactory)



Type B:
Satisfactory or good towards centre of scale eg AirSStil (1=still; 7=draughty)



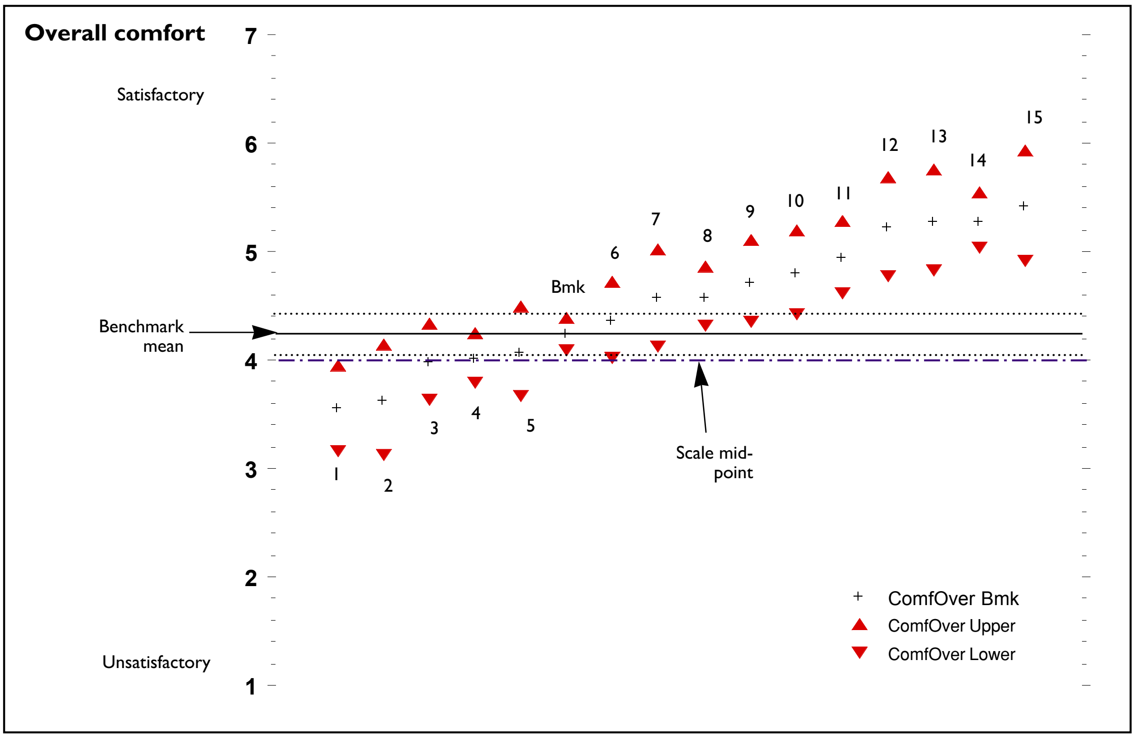
Type C:
Satisfactory or good towards left of scale eg AirSOdur (1=odour free; 7=smelly).



Building names and acronyms used in this report

Probe article number	Full name	Short name	Three-letter
1	Tanfield House	Tanfield	TAN
2	1 Aldermanbury Square	Aldermanbury	ALD
3	Cheltenham and Gloucester	C&G	C&G
4	De Montfort Queens Building	de Montfort	DMQ
5	Cable and Wireless	C&W	C&W
6	Woodhouse Medical Centre	Woodhouse	WMC
7	HFS Gardner House	HFS	HFS
8	APU Queens Building	APU	APU
11	John Cabot City Technology College	Cabot	CAB
12	Rotherham Magistrates Court	RMC	RMC
13	Charities Aid Foundation	CAF	CAF
14	Elizabeth Fry Building	Elizabeth Fry	FRY
16	Marston Book Services	MBS office	MBO
17	Co-operative Retail Services	CRS	CRS
18	The Portland Building	Portland	POR

Figure 1: Overall comfort Probe buildings



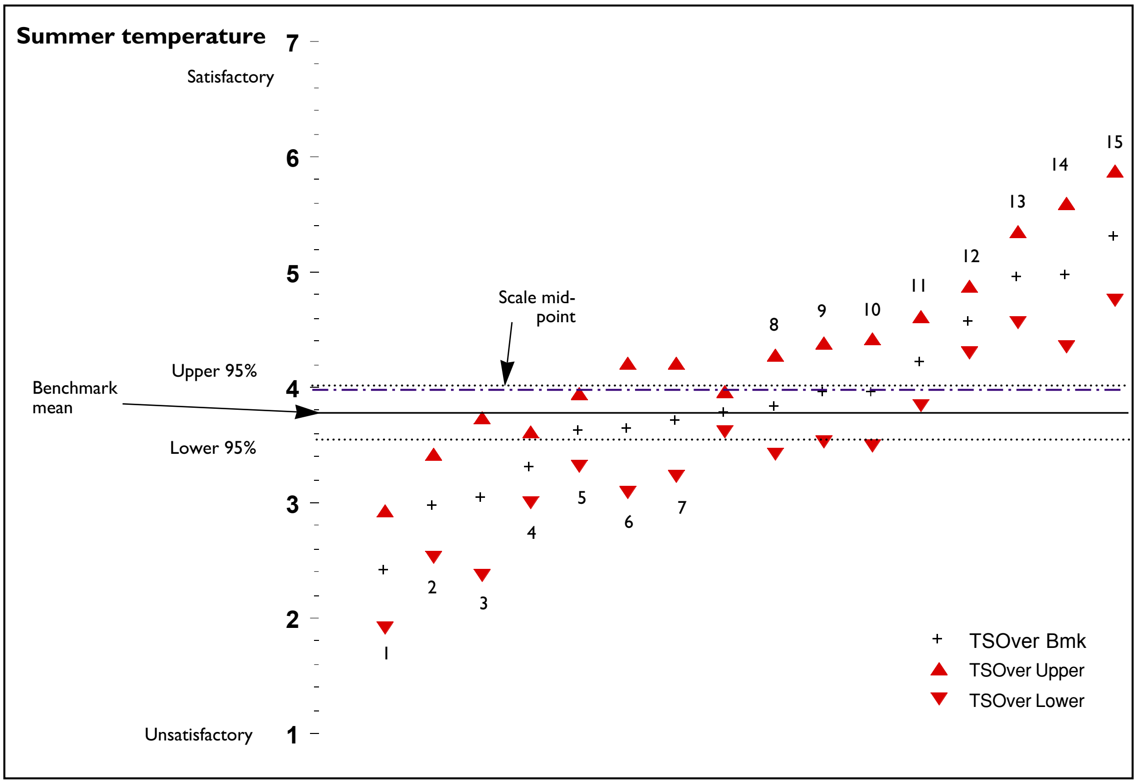
Notes to Figure 1

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Key
1. APU
2. C&W
3. ALD
4. CAF
5. DMQ
   Bmk
6. HFS
7. POR
8. CRS
9. CAB
10. MBO
11. C&G
12. RMC
13. WMC
14. TAN
15. FRY

Figure 2: Summer temperature: Probe buildings



Key

1. C&W
2. CAB
3. WMC
4. CAF
5. CRS
6. POR
7. DMQ

   Bmk

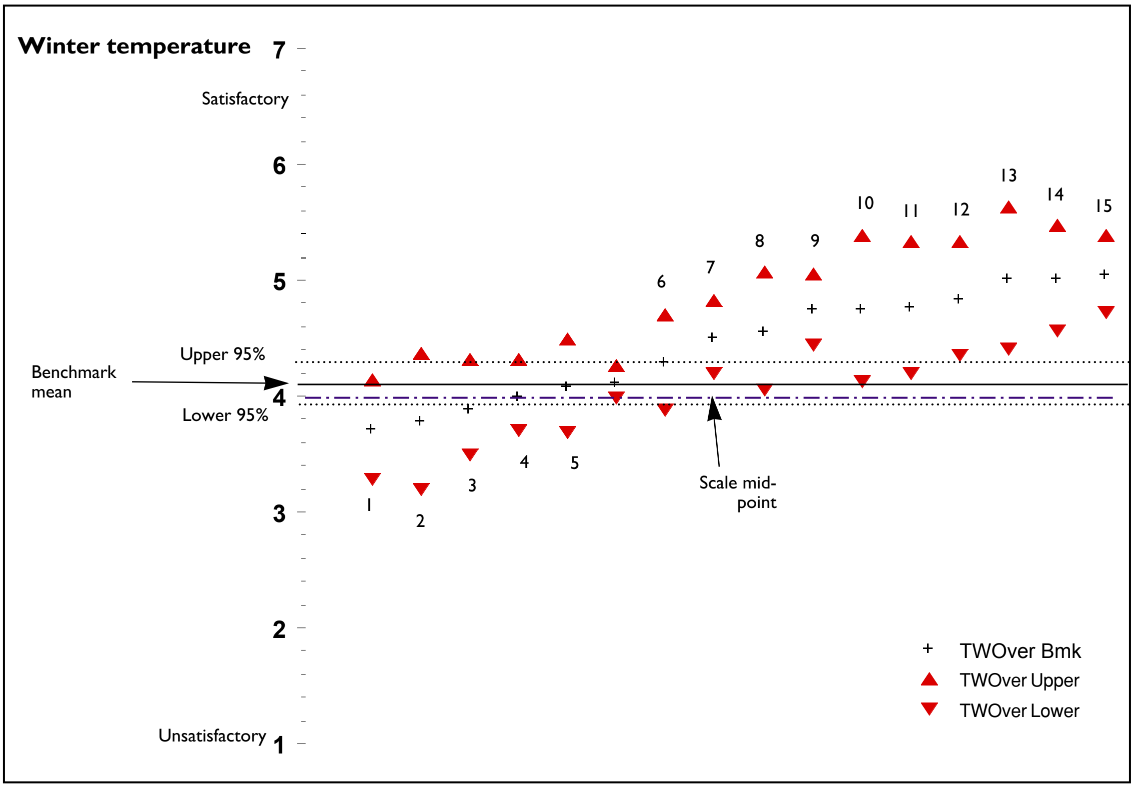
8. APU
9. MBO
10. ALD
11. HFS
12. TAN
13. C&G
14. RMC
15. FRY

Notes to Figure 2

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 3: Winter temperature: Probe buildings



Key

1.	DMQ
2.	C&W
3.	APU
4.	CAF
5.	HFS
	Bmk
6.	ALD
7.	CRS
8.	CAB
9.	TAN
10.	RMC
11.	FRY
12.	POR
13.	WMC
14.	MBO
15.	C&G

Notes to Figure 3

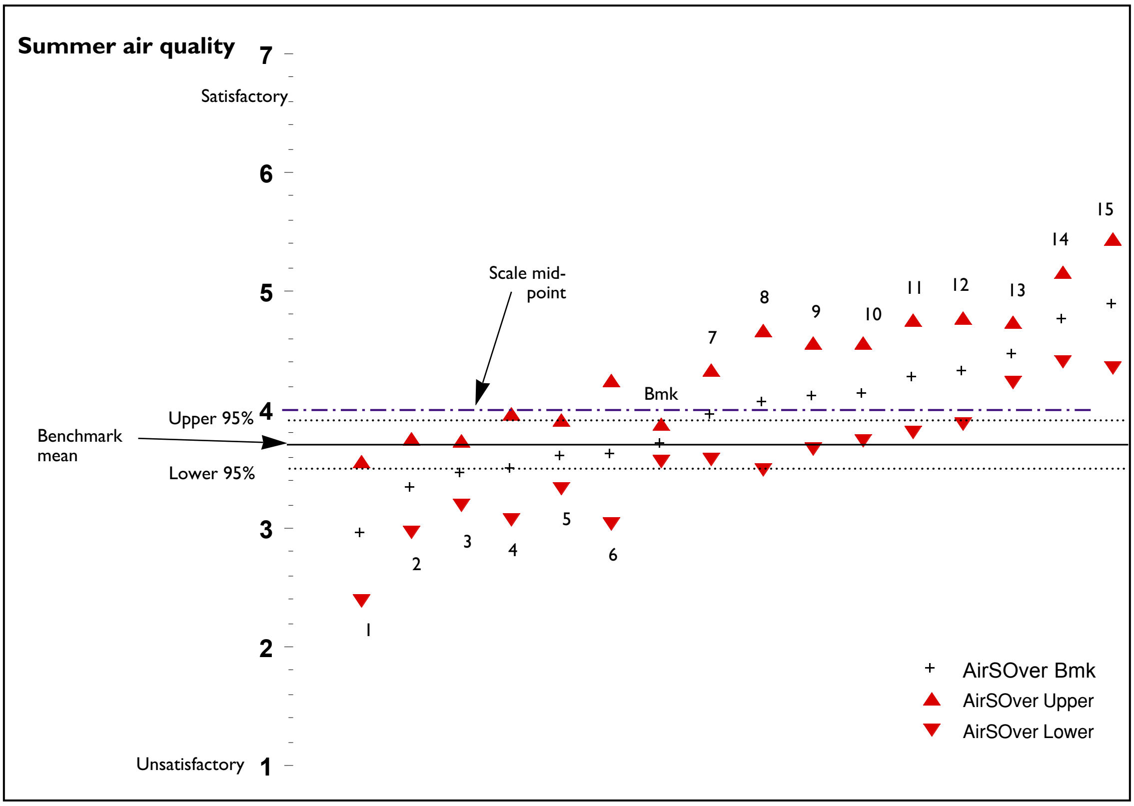
Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

DMQ: One Sample Analysis
Hypothesized Mean = 4

	Mean	DF	t-Value	P-Value	95% Lower	95% Upper
TWOVER	3.68	65	-1.44	.1536	3.24	4.12

Figure 4: Summer air quality: Probe buildings



Key

1. C&W
2. APU
3. CAF
4. CAB
5. CRS
6. WMC

Bmk

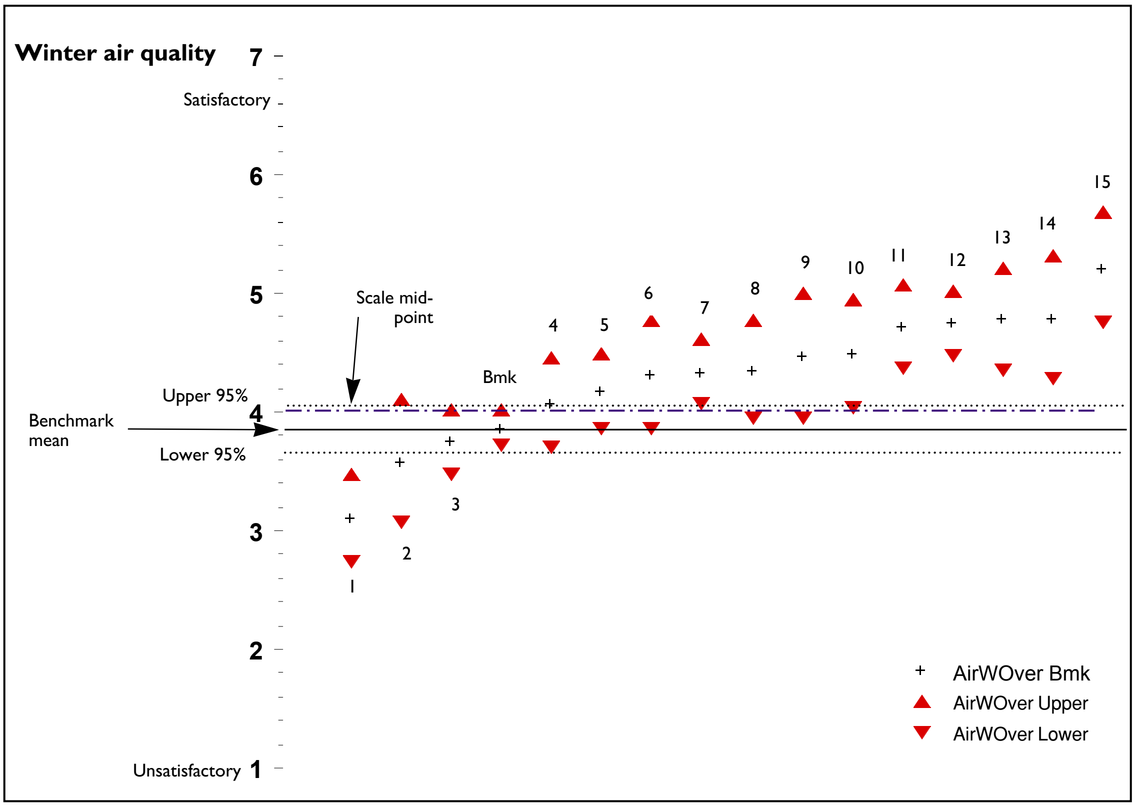
7. HFS
8. RMC
9. DMQ
10. ALD
11. MBO
12. POR
13. TAN
14. C&G
15. FRY

Notes to Figure 4

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 5: Winter air quality: Probe buildings



Key

1. APU
2. C&W
3. CAF

Bmk

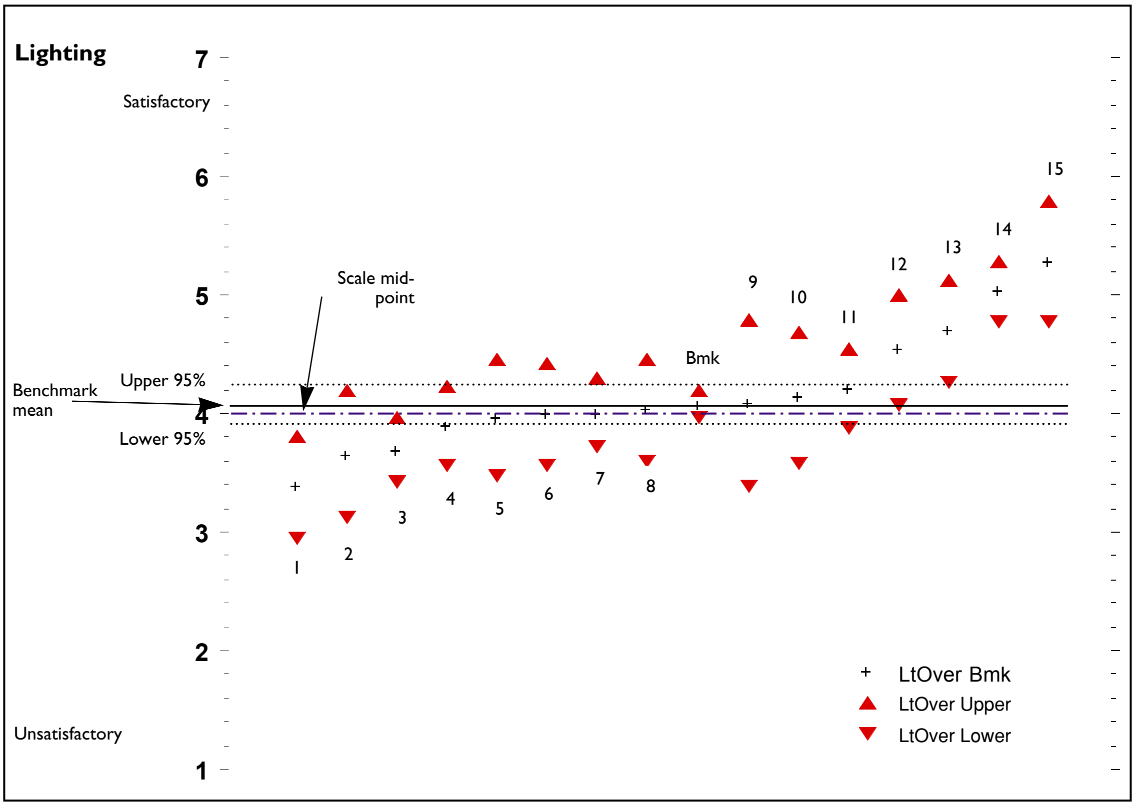
4. HFS
5. ALD
6. CAB
7. CRS
8. DMQ
9. WMC
10. POR
11. C&G
12. TAN
13. MBO
14. RMC
15. FRY

Notes to Figure 5

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 6: Lighting: Probe buildings



Key

1. APU
2. C&W
3. CAF
4. C&G
5. MBO
6. ALD
7. CRS
8. DMQ

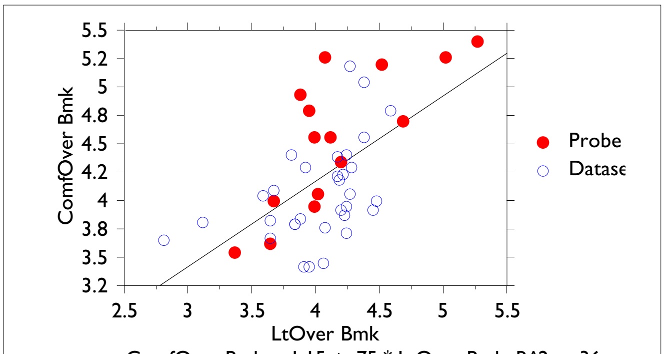
Bmk

9. WMC
10. POR
11. HFS
12. RMC
13. CAB
14. TAN
15. FRY

Notes to Figure 6

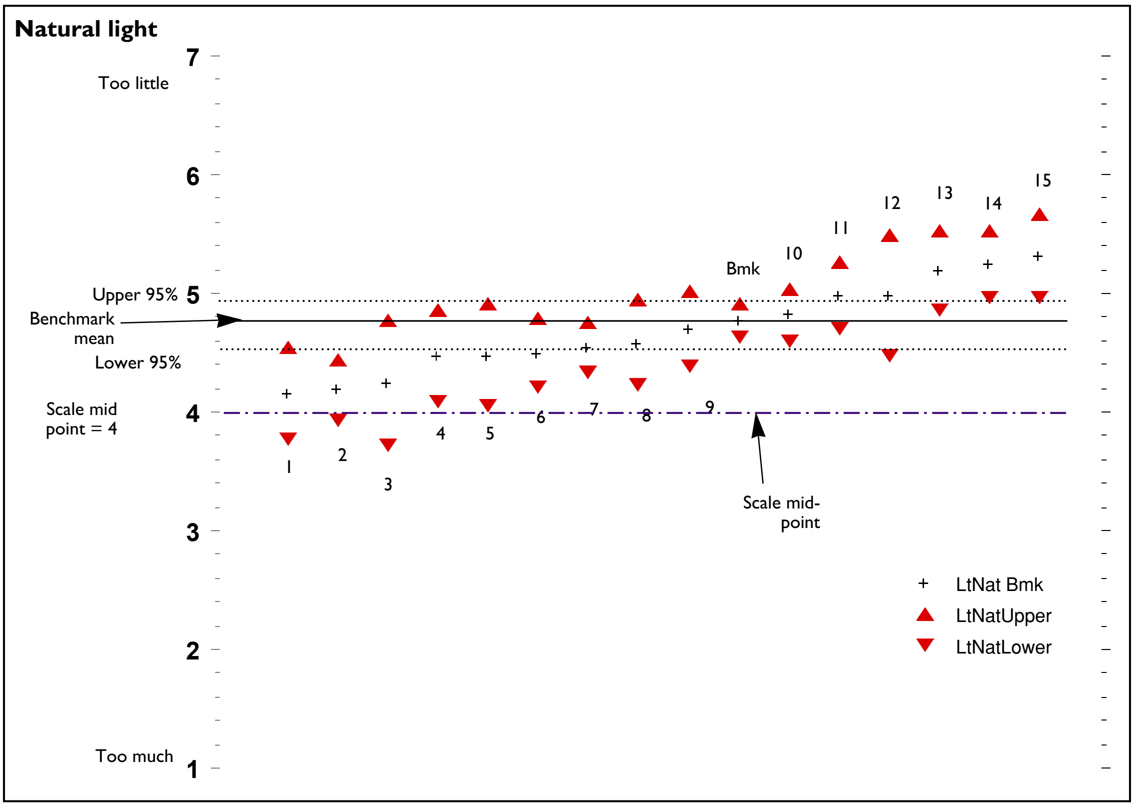
Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.



ComfOver Bmk = 1.15 + .75 * LtOver Bmk; R^2 = .36

Figure 7: Natural light: Probe buildings



Key

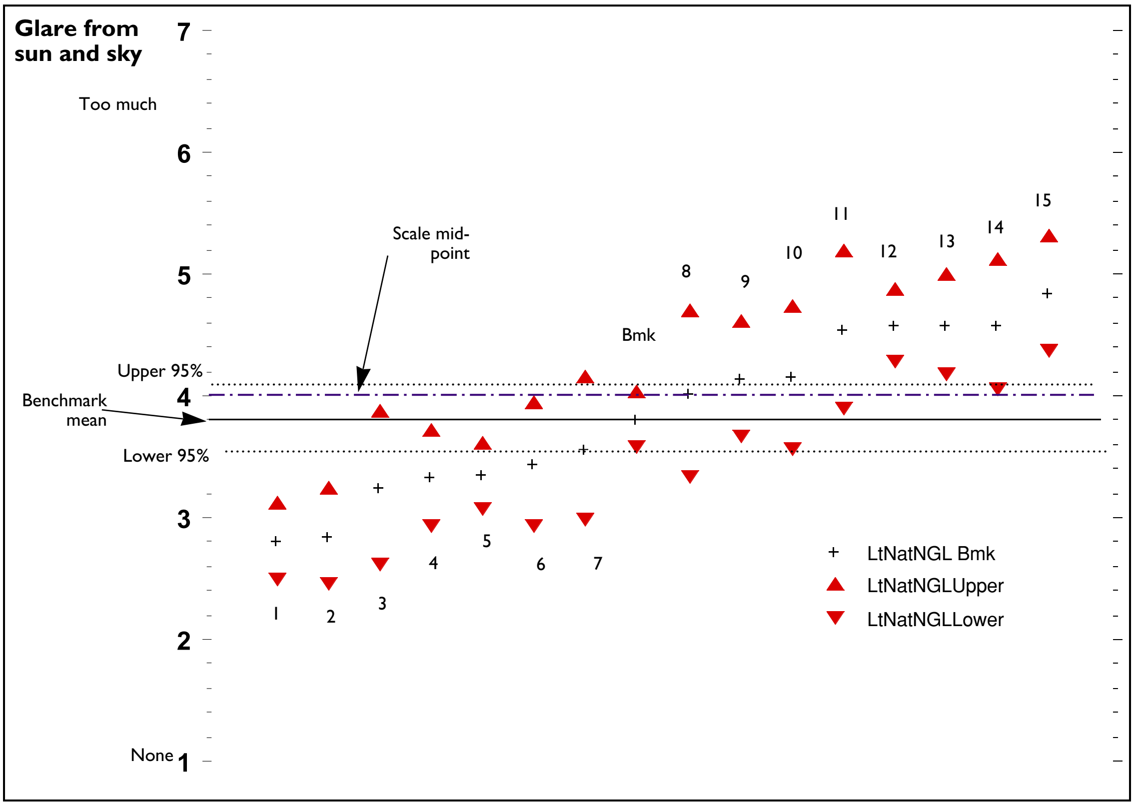
1.	C&W
2.	CAB
3.	RMC
4.	POR
5.	FRY
6.	MBO
7.	TAN
8.	DMQ
9.	APU
	Bmk
10.	CAF
11.	CRS
12.	WMC
13.	ALD
14.	HFS
15.	C&G

Notes to Figure 7

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 8: Glare from sun and sky: Probe buildings



Key

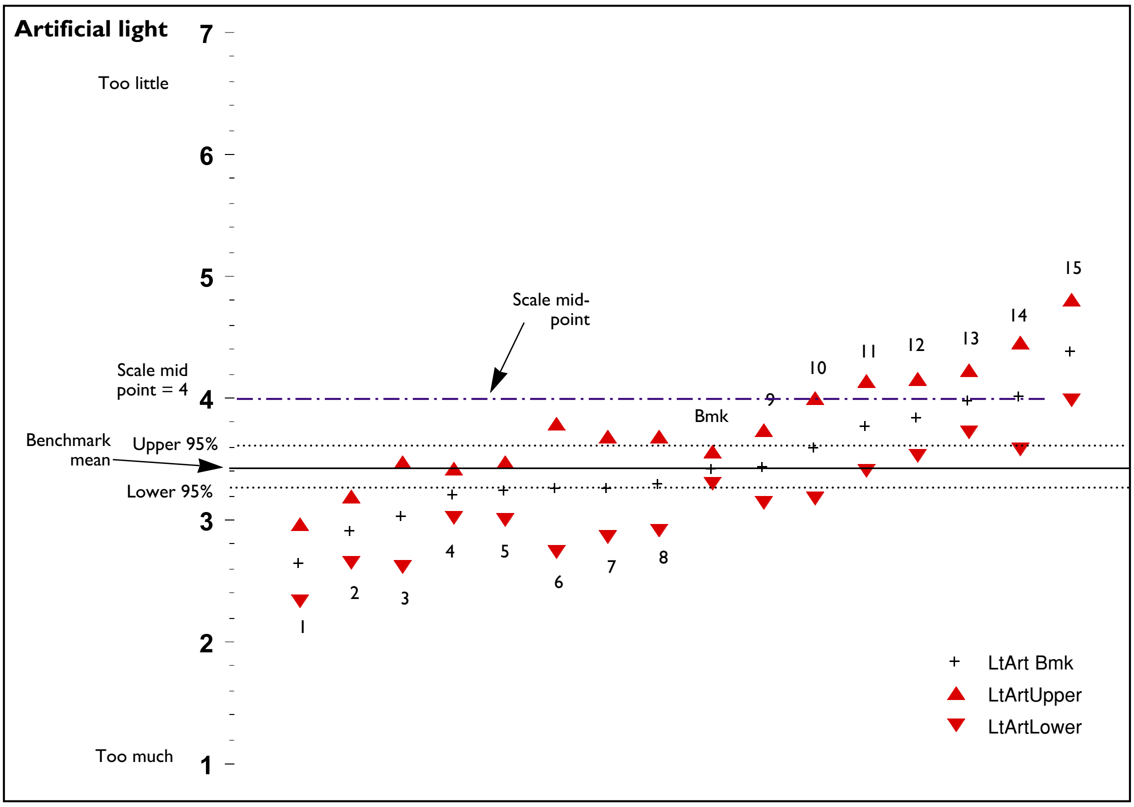
1.	CRS
2.	ALD
3.	WMC
4.	HFS
5.	TAN
6.	C&G
7.	FRY
	Bmk
8.	RMC
9.	DMQ
10.	POR
11.	MBO
12	CAF
13.	CAB
14.	C&W
15.	APU

Notes to Figure 8

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.

Figure 9: Artificial light: Probe buildings



Key

1. C&G
2. HFS
3. ALD
4. TAN
5. CAF
6. RMC
7. MBO
8. FRY

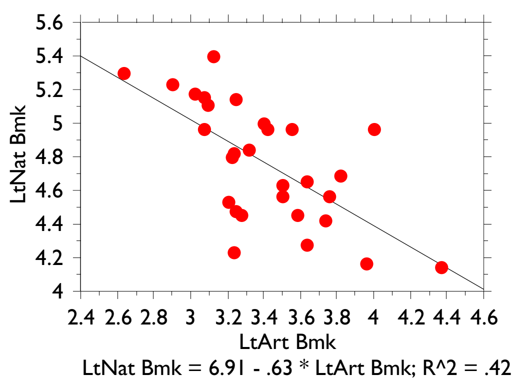
Bmk

9. CRS
10. POR
11. DMQ
12. APU
13. CAB
14. WMC
15. C&W

Notes to Figure 9

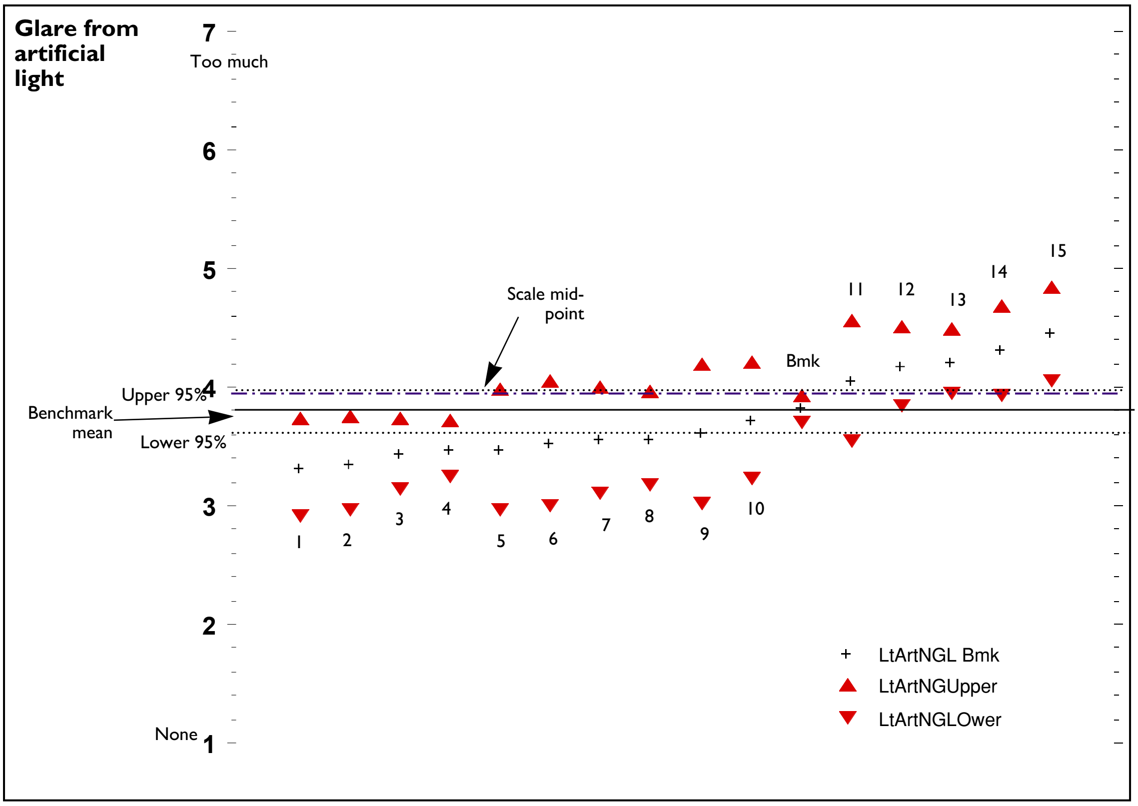
Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.



Scales:
1=Too little:
7= Too much

Figure 10: Glare from artificial light: Probe buildings



Key

1. DMQ
2. CAB
3. CRS
4. TAN
5. RMC
6. FRY
7. WMC
8. APU
9. POR
10. C&W

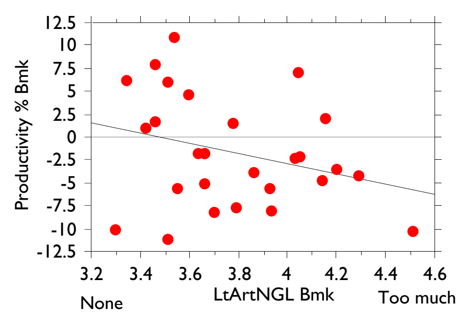
Bmk

11. MBO
12. HFS
13. CAF
14. ALD
15. C&G

Notes to Figure 10

Upper and lower ninety-five per cent confidence intervals are shown for 1) individual building means; 2) Building Use Studies dataset benchmark for 50 buildings.

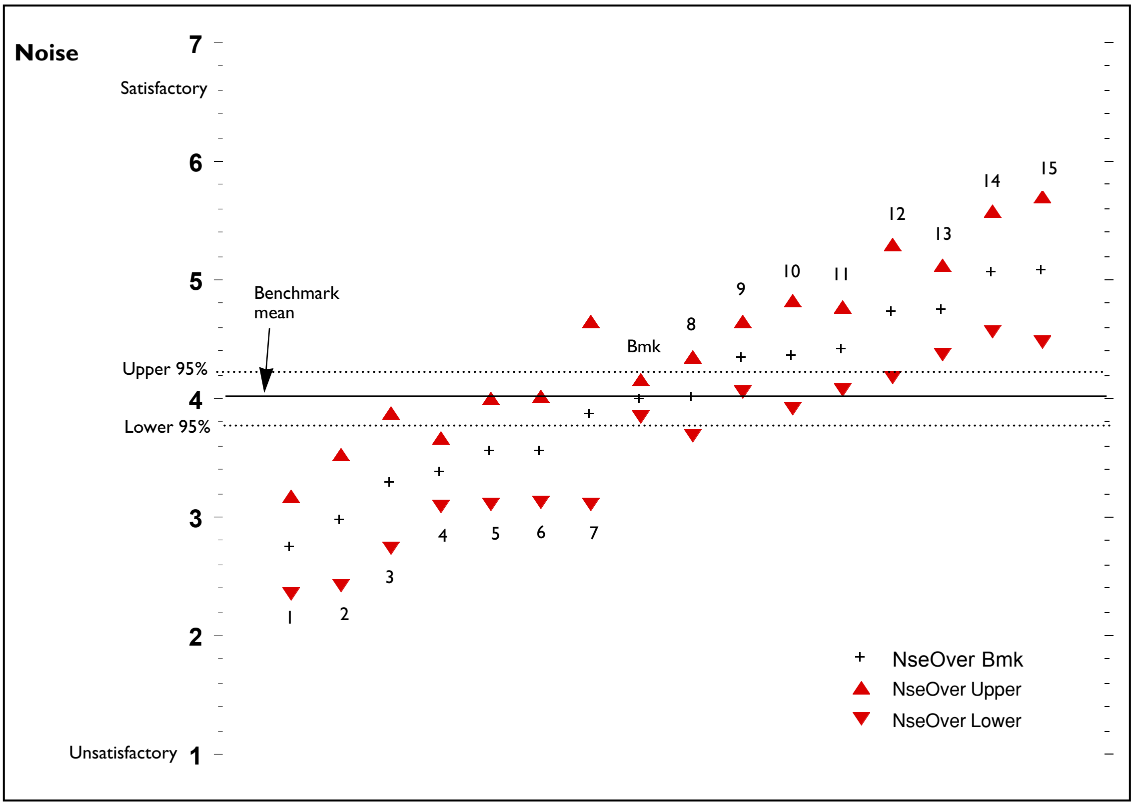
A building mean is significantly different from the benchmark mean if the mean value falls outside the interval range for the benchmark mean. A building mean is significantly different from another building if its mean value falls outside the interval range for that building.



Productivity % Bmk = 19.08 - 5.5 * LtArtNGL Bmk; R^2 = .08

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	78.76	78.76	2.35	.1375
Residual	26	871.96	33.54		
Total	27	950.72			

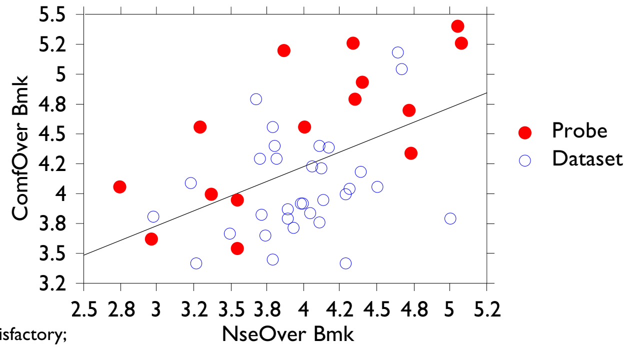
Figure 11: Noise: Probe buildings



Key

1.	DMQ
2.	C&W
3.	POR
4.	CAF
5.	APU
6.	ALD
7.	RMC
	Bmk
8.	CRS
9.	TAN
10.	MBO
11.	C&G
12.	CAB
13.	HFS
14.	FRY
15.	WMC

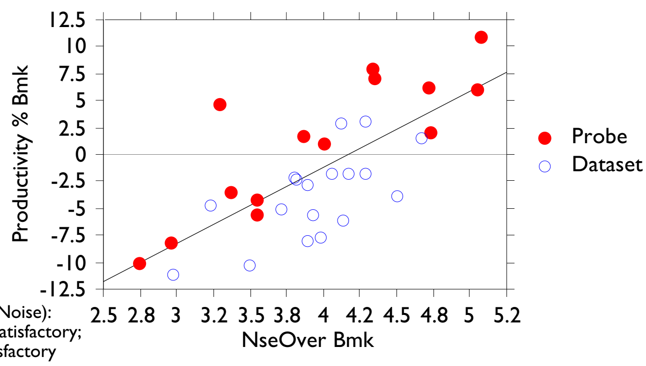
Supplementary graphs for Figure 11



Scales:
1=Unsatisfactory;
7=Satisfactory

ComfOver Bmk = 2.26 + .49 * NseOver Bmk; R^2 = .24

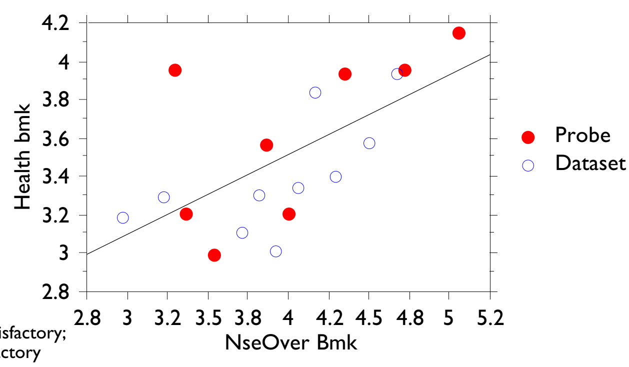
	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	7670.37	7670.37	10.93	.0019
Residual	45	31570.61	701.57		
Total	46	39240.98			



Scale (Noise):
1=Unsatisfactory;
7=Satisfactory

Productivity % Bmk = -29.39 + 7.04 * NseOver Bmk; R^2 = .51

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	520.64	520.64	31.56	<.0001
Residual	30	494.98	16.50		
Total	31	1015.62			

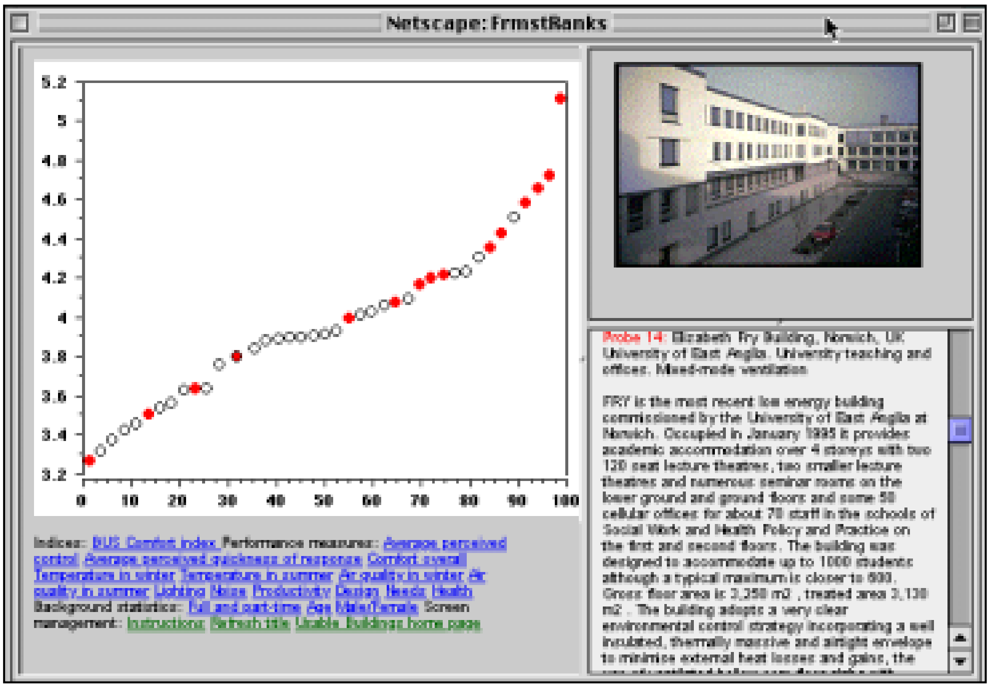


Scales:
1=Unsatisfactory;
7=Satisfactory

Health bmk = 1.84 + .42 * NseOver Bmk; R^2 = .4

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	.95	.95	10.66	.0049
Residual	16	1.43	.09		
Total	17	2.38			

Figure 12: Probe buildings for overall comfort variable



These are screenshots from a web-enabled graphic developed by Building Use Studies. It is available in a live version on the Usable Buildings website (www.usablebuildings.co.uk).

By clicking on each of the red data points you will be able to access a picture and short description for each of the Probe buildings (top screen) and data, including benchmark tests and histograms, for each of the 19 variables listed (bottom screen).

The example shown is for the Overall Comfort variable (ComfOver) for The Elizabeth Fry Building (FRY).

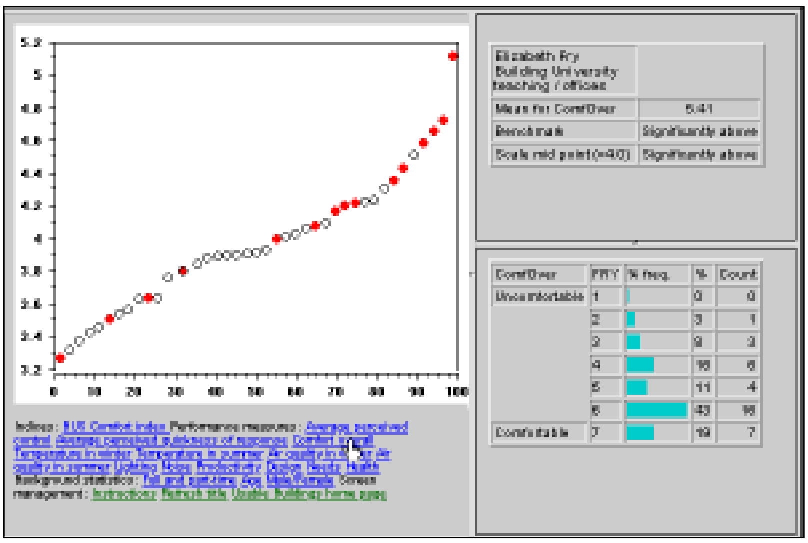


Figure 13
Probe buildings on major comfort variables relative to BUS benchmarks

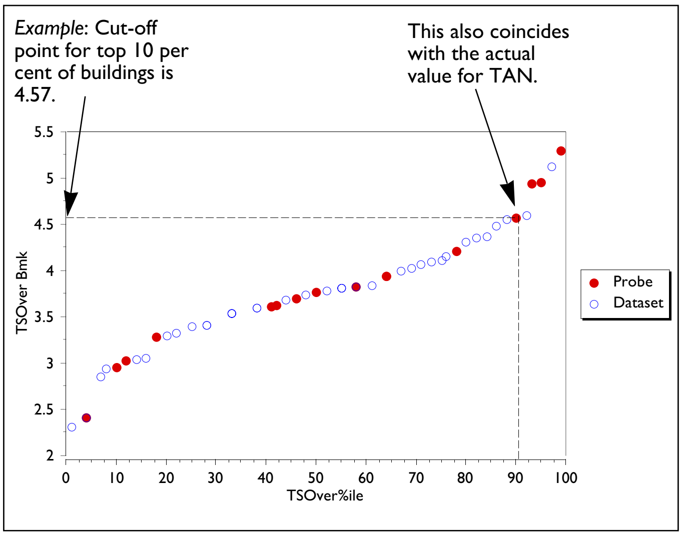
	TSOver		TWOver		AirSOver		AirWOver		LtOver		NseOver		ComfOver		Average %ile	
	Mean		Mean		Mean		Mean		Mean		Mean		Mean		Mean	
1 Tanfield House	4.57	**90**	4.73	**83**	4.46	**95**	4.73	**93**	5.01	**97**	4.33	**77**	5.27	**96**	4.73	**97**
2 1 Aldermanbury Square	3.94	**62**	4.28	**67**	4.13	**82**	4.16	**71**	3.98	**38**	3.55	**19**	3.96	**37**	4.00	**57**
3 Cheltenham and Gloucester	4.94	**93**	5.03	**99**	4.76	**97**	4.7	**92**	3.88	**27**	4.4	**83**	4.93	**87**	4.66	**94**
4 De Montfort Queens Building	3.7	**44**	3.7	**18**	4.1	**78**	4.34	**84**	4.01	**44**	2.74	**1**	4.06	**48**	3.81	**31**
5 Cable and Wireless	2.41	**4**	3.77	**24**	2.95	**8**	3.57	**29**	3.64	**12**	2.96	**3**	3.62	**9**	3.27	**1**
6 Woodhouse Medical Centre	3.03	**12**	5	**96**	3.62	**41**	4.46	**86**	4.07	**51**	5.07	**99**	5.27	**96**	4.36	**85**
7 HFS Gardner House	4.21	**78**	4.07	**51**	3.94	**63**	4.06	**64**	4.2	**64**	4.73	**93**	4.35	**66**	4.22	**76**
8 APU Queens Building	3.83	**57**	3.88	**35**	3.34	**24**	3.09	**7**	3.36	**5**	3.54	**17**	3.54	**7**	3.51	**13**
11 John Cabot CTC	2.96	**10**	4.55	**78**	3.5	**32**	4.3	**78**	4.68	**95**	4.72	**91**	4.71	**81**	4.20	**73**
12 Rotherham Magistrates Court	4.96	**95**	4.74	**86**	4.06	**76**	4.78	**97**	4.52	**91**	3.86	**38**	5.21	**93**	4.59	**92**
13 Charities Aid Foundation	3.29	**18**	3.99	**43**	3.45	**28**	3.73	**41**	3.67	**17**	3.36	**13**	4.00	**42**	3.64	**22**
14 Elizabeth Fry Building	5.30	**99**	4.75	**88**	4.88	**99**	5.20	**99**	5.26	**99**	5.05	**97**	5.41	**99**	5.12	**99**
16 Marston Book Services	3.94	**62**	5.00	**96**	4.26	**86**	4.77	**95**	3.94	**34**	4.35	**79**	4.79	**84**	4.44	**87**
17 Co-operative Retail Services	3.61	**39**	4.49	**76**	3.60	**39**	4.32	**80**	3.99	**40**	4.00	**53**	4.57	**79**	4.08	**66**
18 The Portland Building	3.63	**41**	4.83	**90**	4.31	**90**	4.48	**88**	4.12	**54**	3.29	**11**	4.56	**74**	4.17	**71**
Benchmark (1999)	3.77	**48**	4.11	**56**	3.70	**47**	3.85	**49**	4.06	**48**	3.99	**49**	4.22	**57**	3.96	**52**
Scale midpoint	4.00	**66**	4.00	**46**	4.00	**70**	4.00	**59**	4.00	**42**	4.00	**53**	4.00	**42**	4.00	**55**
All Probe average																**62**
All non-Probe average																**42**

Notes to Figure 13
Variable names

TSOver	Summer temperature
TWOver	Winter temperature
AirSOver	Summer air quality
AirWOver	Winter air quality
LtOver	Lighting
NseOver	Noise
ComfOver	Overall comfort
Average%ile	Average percentile

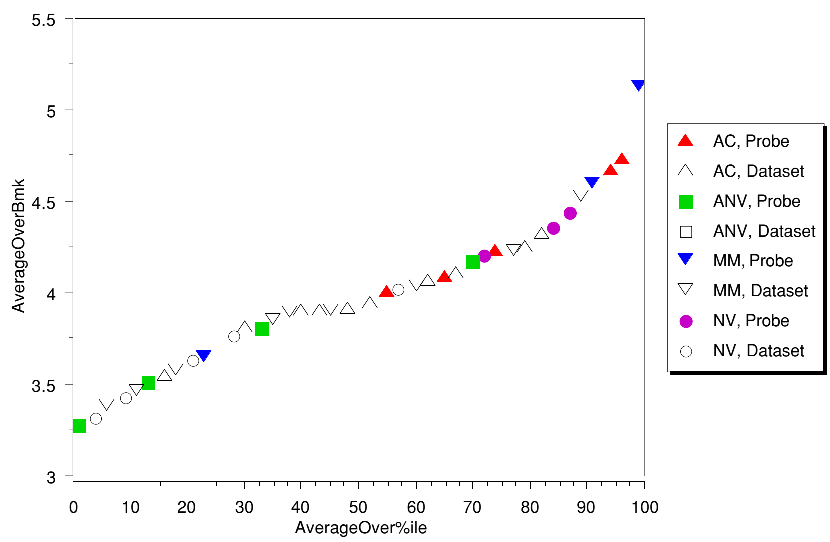
Variable scales
Type A - right-handed - best on right.
1=Low/poor; 7=High/good

Percentile
Percentiles allow answers to questions such as "What value is the cut-off point, where such-and-such a percentage of cases is equal to or smaller than that value?" For example, if you are interested in the top 10 per cent of buildings for the temperature in summer variable (TSOver), the cut-off point is 4.57 - which is also the value of the TSOver variable for TAN in the diagram (right).



To covert raw data to percentiles (StatView notation):
(Rank(*variable*,AllRows)-0.5)/Count(*variable*,AllRows)*100

Figure 14
Ranked average percentiles for Probe and other buildings split by ventilation type.



Notes to Figure 14

Average Overall score
A score based on the average scores of the following seven summary variables.

TSOver	Summer temperature
TWOver	Winter temperature
AirSOver	Summer air quality
AirWOver	Winter air quality
LtOver	Lighting
NseOver	Noise
ComfOver	Overall comfort

Average Overall percentile
A percentile based on the Average Overall score.

Example
TAN scores an average of 4.73 (see Figure 13, first row) on the seven summary variables. When converted to a percentile (see formula in Figure 13) this evaluates to 97. Thus TAN is in the top 5% of the dataset by this criterion.

Scales
Type A. Best on right

Ventilation types

NV	Natural
ANV	Advanced natural
MM	Mixed mode
AC	Air conditioned

Interpretation
For the average percentile variable, all dataset buildings have been a) ranked into order from worse to best (left to right on bottom axis); b) split into four ventilation types c) plotted showing rank against average percentile. The buildings in the top right of the graph are “best” by these criteria.

Figure 15: All BUS dataset buildings: differences between ventilation types for average percentiles.

	Count	Mean	Std. Dev.	Std. Err.
AC	15	4.09	.31	.08
ANV	4	3.69	.39	.19
MM	12	4.01	.52	.15
NV	8	3.90	.42	.15

	Vent type	Residual
DF	3	35
Sum of Squares	.60	6.00
Mean Square	.20	.17
F-Value	1.16	
P-Value	.3391	
Lambda	3.48	
Power	.28	

	Count	Mean	Std. Dev.	Std. Err.
AC	15	60.20	22.88	5.91
ANV	4	29.25	30.20	15.10
MM	12	49.33	33.07	9.55
NV	8	45.25	33.81	11.95

Notes to Figure 15

The analysis of variance shows no significant difference between ventilation types for the average percentile variable (left). Differences between mean scores for average comfort are also shown (above). Air conditioned (AC) and mixed mode (MM) are best; ANV worse.

Sample sizes are small for ANV, but the ANOVA analysis takes this into account.

Figure 16: Probe buildings for productivity and forgiveness scores relative to BUS benchmarks

	Productivity %		Forgiveness ratio	
	Mean		Mean	
Tanfield House	8	**97**	1.14	**77**
1 Aldermanbury Square	-4.2	**43**	0.99	**23**
Cheltenham and Gloucester	.	**.**	1.07	**52**
De Montfort Queens Building	-10	**11**	1.08	**56**
Cable and Wireless	-8.1	**17**	1.13	**74**
Woodhouse Medical Centre	10.9	**99**	1.25	**99**
HFS Gardner House	2.1	**79**	1.04	**34**
APU Queens Building	-5.6	**28**	1.01	**28**
John Cabot CTC	6.3	**90**	1.14	**85**
Rotherham Magistrates Court	1.8	**77**	1.16	**93**
Charities Aid Foundation	-3.50	**50**	1.12	**68**
Elizabeth Fry Building	6.20	**88**	1.07	**50**
Marston Book Services	7.10	**94**	1.09	**62**
Co-operative Retail Services	1.10	**72**	1.14	**81**
The Portland Building	4.80	**86**	1.11	**66**
Benchmark (1999)	-2.60	**57**	1.08	**58**
Scale midpoint	0.00	**70**	1.00	**26**
All Probe average		**66.5**		
All non-Probe average		**41.1**		

Notes to Figure 16

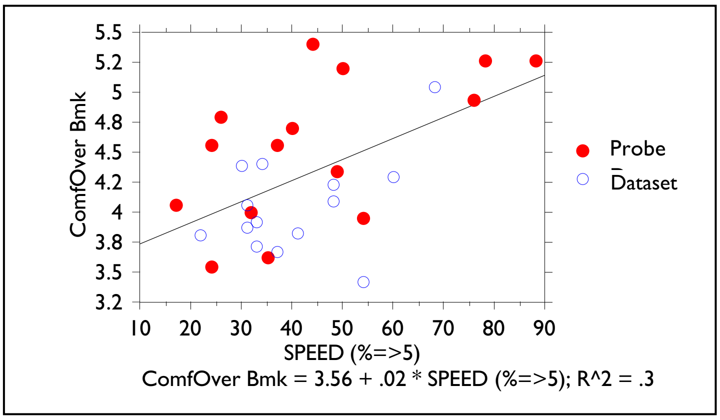
Productivity is based on perceived productivity ratings.

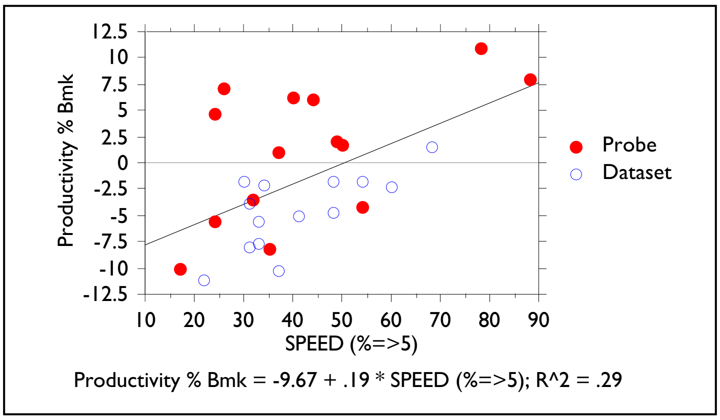
Forgiveness ratio is ComfOver divided by the average of (TSOver, TWOver, AirSOver, AirWOver, LtOver,NseOver). A score greater than 1 (unity) indicates that occupants tolerate faults in detailed performance.

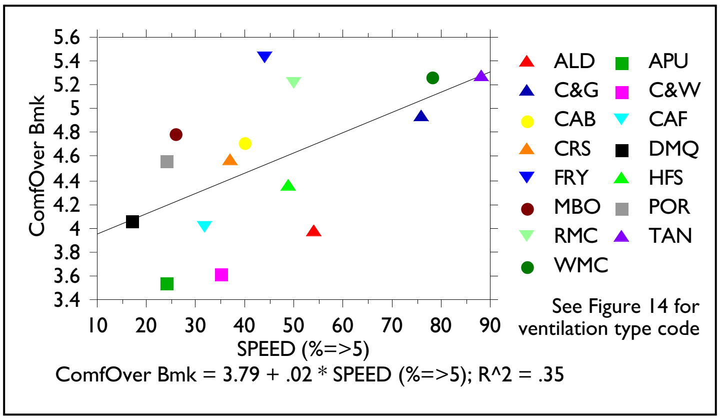
Dataset

Data on productivity not collected at C&G.

Figure 17: Probe buildings: Speed of response and overall comfort







Notes to Figure 17

Speed of response is measured by percentages of occupants rating response of facilities management as satisfactory (5-7 on rating scale) when occupants made a complaint about heating, lighting or ventilation systems.

ComfOver Bmk is the overall comfort variable from the benchmark data set.

Figure 18: Probe buildings on major temperature variables relative to BUS benchmarks

	1=stable; 7=varies		1=too hot; 7=too cold		1=stable; 7=varies		1=too hot; 7=too cold	
	TSStable		TSHot		TWStable		TWHot	
	Mean		Mean		Mean		Mean	
1 Tanfield House	3.95	**18**	3.45	**68**	4.08	**19**	4.18	**45**
2 1 Aldermanbury Square	4.49	**69**	3.2	**52**	4.21	**30**	4.26	**57**
3 Cheltenham and Gloucester	3.78	**8**	3.98	**90**	4.04	**16**	3.82	**18**
4 De Montfort Queens Building	4.02	**25**	2.71	**20**	4.29	**39**	4.33	**62**
5 Cable and Wireless	3.66	**4**	2.26	**5**	4.08	**19**	4.34	**66**
6 Woodhouse Medical Centre	3.81	**14**	2.75	**22**	4.22	**33**	4.26	**57**
7 HFS Gardner House	4.91	**97**	4.43	**97**	4.74	**71**	4.7	**90**
8 APU Queens Building	4.16	**29**	2.63	**18**	4.21	**30**	3.53	**5**
11 John Cabot CTC	4.37	**54**	2.51	**10**	3.81	**8**	4.56	**86**
12 Rotherham Magistrates Court	4	**23**	3.68	**78**	4.3	**41**	4.13	**40**
13 Charities Aid Foundation	4.55	**78**	2.53	**12**	4.39	**52**	4.39	**72**
14 Elizabeth Fry Building	3.66	**4**	3.46	**71**	3.32	**1**	4.53	**84**
16 Marston Book Services	4.21	**32**	2.98	**39**	3.83	**10**	4.11	**37**
17 Co-operative Retail Services	4.65	**93**	3.02	**41**	4.32	**44**	3.92	**29**
18 The Portland Building	4.25	**39**	2.78	**25**	3.69	**5**	3.42	**3**
Benchmark (1999)	4.29	**46**	3.18	**50**	4.44	**55**	4.19	**48**
Scale midpoint	4.00	**23**	4	**92**	4	**14**	4	**33**
All Probe average		**39**		**43**		**28**		**50**
All non-Probe average		**55**		**52**		**60**		**50**

Notes to Figure 18

Variable names

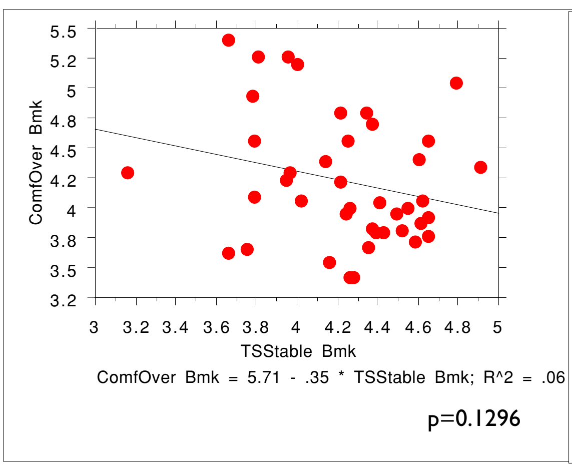
TSHot Summer temperature too hot/ too cold
TWHot Winter temperature too hot/ too cold
TSStable Summer temperature stable/varies
TWStable Winter temperature stable/varies

Variable scales

See column headings

Interpretation

<50%ile increasingly unsatisfactory: >50%ile increasingly satisfactory.
50th percentile is median (middle) observation in ranked list.



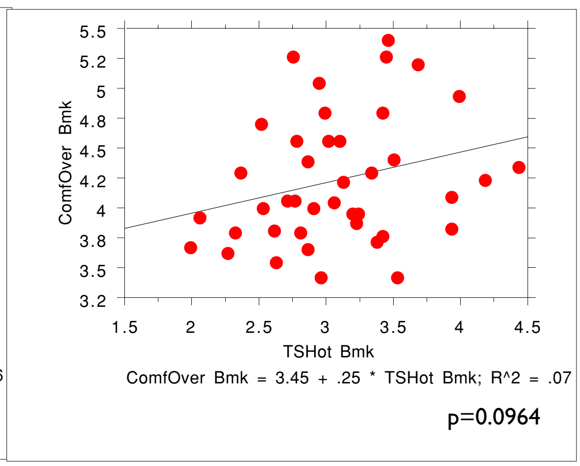


Figure 19: Probe buildings on major air quality variables relative to BUS benchmarks

	1=still; 7=draughty AirSStill		1=dry; 7=humid AirSDry		1=fresh; 7=stuffy AirSFresh		1=odourless 7=smelly AirSOdur	
	Mean		Mean		Mean		Mean	
1 Tanfield House	3.36	**80**	3.52	**67**	4.16	**23**	3.57	**61**
2 1 Aldermanbury Square	3.12	**68**	3.85	**78**	4.42	**44**	3.22	**32**
3 Cheltenham and Gloucester	3.61	**93**	3.38	**45**	3.64	**1**	3.03	**10**
4 De Montfort Queens Building	2.8	**29**	3.5	**64**	4.3	**33**	3.2	**25**
5 Cable and Wireless	2.18	**1**	4.18	**93**	5.64	**94**	4.43	**93**
6 Woodhouse Medical Centre	2.21	**3**	3.57	**69**	5.34	**88**	3.96	**77**
7 HFS Gardner House	3.63	**95**	2.94	**8**	4.32	**38**	2.45	**1**
8 APU Queens Building	2.3	**10**	2.89	**6**	5.17	**81**	2.96	**8**
11 John Cabot CTC	2.25	**8**	4.46	**97**	5.36	**90**	4.06	**84**
12 Rotherham Magistrates Court	2.86	**39**	3.39	**48**	4.65	**68**	3.3	**38**
13 Charities Aid Foundation	2.36	**14**	4.06	**90**	5.21	**83**	3.44	**48**
14 Elizabeth Fry Building	2.63	**20**	3.61	**73**	3.7	**5**	3.06	**15**
16 Marston Book Services	2.81	**31**	4.49	**99**	4.52	**56**	2.55	**3**
17 Co-operative Retail Services	3.05	**56**	3.78	**76**	4.95	**78**	2.94	**7**
18 The Portland Building	2.82	**34**	3.5	**64**	4.31	**35**	3.15	**22**
Benchmark (1999)	2.94	**46**	3.46	**54**	4.56	**60**	3.53	**56**
Scale midpoint	4	**99**	4	**88**	4	**12**	4	**81**
All Probe average		**39**		**65**		**54**		**39**
All non-Probe average		**53**		**43**		**49**		**55**

	1=still; 7=draughty AirWStill		1=dry; 7=humid AirWDry		1=fresh; 7=stuffy AirWFresh		1=odourless 7=smelly AirWOdur	
	Mean		Mean		Mean		Mean	
1 Tanfield House	3.36	**44**	3.34	**86**	3.99	**17**	3.27	**50**
2 1 Aldermanbury Square	3.41	**50**	3.55	**97**	4.36	**43**	2.95	**18**
3 Cheltenham and Gloucester	3.38	**46**	3.09	**55**	4.35	**41**	2.78	**8**
4 De Montfort Queens Building	2.6	**7**	3.2	**69**	4.3	**38**	3.2	**38**
5 Cable and Wireless	4.5	**95**	3.36	**88**	4.78	**78**	4	**85**
6 Woodhouse Medical Centre	2.47	**5**	3.32	**84**	4.67	**76**	3.73	**76**
7 HFS Gardner House	4.42	**93**	2.99	**44**	4.04	**22**	2.36	**3**
8 APU Queens Building	3.28	**42**	2.23	**1**	5.36	**94**	3.03	**24**
11 John Cabot CTC	2.92	**20**	3.03	**49**	3.97	**15**	3.65	**73**
12 Rotherham Magistrates Court	2.84	**14**	2.24	**3**	5.08	**92**	3.52	**66**
13 Charities Aid Foundation	3.75	**75**	2.91	**34**	4.96	**85**	3.25	**47**
14 Elizabeth Fry Building	2.44	**3**	3.2	**69**	4.15	**27**	3.1	**27**
16 Marston Book Services	3.80	**82**	3.09	**55**	4.37	**48**	2.3	**1**
17 Co-operative Retail Services	3.05	**31**	3.15	**63**	4.37	**45**	2.78	**7**
18 The Portland Building	2.95	**24**	3.32	**82**	4.54	**69**	3.12	**29**
Benchmark (1999)	3.4	**48**	3.01	**46**	4.43	**59**	3.38	**59**
Scale midpoint	4	**86**	4	**99**	4	**20**	4	**85**
All Probe average		**42**		**59**		**53**		**37**
All non-Probe average		**52**		**45**		**49**		**54**

Notes to Figure 19

Variable names

AirSStill Summer air still/draughty
AirSDry Summer air dry/humid
AirSFresh Summer air fresh/stuffy
ASOdur Summer air odourless/smelly

Winter as summer: AirWStill etc.

Variable scales

See columns

Figure 20: Probe buildings on major lighting variables relative to BUS benchmarks

	1=too much; 7=too little LtNat		1=no glare 7=too much glare LtNatNgl		1=too much; 7=too little LtArt		1=no glare 7=too much glare LtArtNgl	
	Mean		Mean		Mean		Mean	
1 Tanfield House	4.53	**31**	3.33	**21**	3.2	**24**	3.46	**13**
2 1 Aldermanbury Square	5.18	**89**	2.83	**8**	3.02	**8**	4.29	**92**
3 Cheltenham and Gloucester	5.3	**95**	3.42	**31**	2.63	**2**	4.43	**95**
4 De Montfort Queens Building	4.57	**37**	4.12	**69**	3.75	**82**	3.3	**2**
5 Cable and Wireless	4.14	**5**	4.57	**90**	4.37	**98**	3.7	**47**
6 Woodhouse Medical Centre	4.97	**69**	3.23	**15**	4	**94**	3.54	**24**
7 HFS Gardner House	5.23	**92**	3.31	**18**	2.9	**5**	4.15	**85**
8 APU Queens Building	4.69	**47**	4.83	**95**	3.82	**85**	3.55	**27**
11 John Cabot CTC	4.17	**8**	4.57	**90**	3.96	**89**	3.34	**5**
12 Rotherham Magistrates Court	4.23	**11**	4	**61**	3.24	**32**	3.46	**13**
13 Charities Aid Foundation	4.80	**53**	4.56	**85**	3.22	**27**	4.2	**89**
14 Elizabeth Fry Building	4.46	**24**	3.55	**40**	3.28	**44**	3.51	**18**
16 Marston Book Services	4.48	**27**	4.52	**82**	3.25	**39**	4.04	**76**
17 Co-operative Retail Services	4.96	**66**	2.79	**5**	3.42	**56**	3.42	**8**
18 The Portland Building	4.46	**21**	4.14	**73**	3.58	**69**	3.6	**31**
Benchmark (1999)	4.76	**50**	3.79	**53**	3.41	**53**	3.8	**56**
Scale midpoint	4	**2**	4	**61**	4	**94**	4	**69**
All Probe average		**45**		**52**		**50**		**42**
All non-Probe average		**59**		**46**		**46**		**57**

Notes to Figure 19

Variable names

LtNat Natural light too much/too little
LtNatNgl Natural light no glare/too much glare from sun and sky
LtArt Artificial light too much/too little
LtArtNgl Artificial light no glare/too much from artificial light.

Variable scales

See columns in table

Figure 21: Probe buildings on noise variables relative to BUS benchmarks

	1=unsatisfctory 7=satisfactory NseOver	
	Mean	%ile
1 Tanfield House	4.33	**77**
2 1 Aldermanbury Square	3.55	**19**
3 Cheltenham and Gloucester	4.4	**83**
4 De Montfort Queens Building	2.74	**1**
5 Cable and Wireless	2.96	**3**
6 Woodhouse Medical Centre	5.07	**99**
7 HFS Gardner House	4.73	**93**
8 APU Queens Building	3.54	**17**
11 John Cabot CTC	4.72	**91**
12 Rotherham Magistrates Court	3.86	**38**
13 Charities Aid Foundation	3.36	**13**
14 Elizabeth Fry Building	5.05	**97**
16 Marston Book Services	4.35	**79**
17 Co-operative Retail Services	4.00	**53**
18 The Portland Building	3.29	**11**
Benchmark (1999)	3.99	**49**
Scale midpoint	4	**53**
All Probe average		**52**
All non-Probe average		**49**

Notes to Figure 21
Variable names
NseOver Noise overall unsatisfactory/satisfactory.

Figure 22: Probe buildings on control variables relative to BUS benchmarks

1=no control 7=high control		CntHt		CntCo		CntVt		CntLt		CntNse	
		Mean	%ile	Mean	%ile	Mean	%ile	Mean	%ile	Mean	%ile
1	Tanfield House	1.36	**21**	1.48	**18**	1.75	**27**	2.32	**24**	1.76	**38**
2	1 Aldermanbury Square	1.78	**46**	1.72	**24**	1.26	**14**	1.98	**16**	1.17	**1**
3	Cheltenham and Gloucester	.	**.**	.	**.**	.	**.**	.	**.**	.	**.**
4	De Montfort Queens Building	1.8	**48**	2.4	**49**	3.7	**68**	4.5	**71**	1.9	**49**
5	Cable and Wireless	2.4	**64**	2.83	**66**	3.77	**71**	3.83	**56**	2.26	**68**
6	Woodhouse Medical Centre	4.93	**99**	3.93	**91**	5.1	**97**	4.5	**71**	3.4	**97**
7	HFS Gardner House	1.27	**17**	1.27	**9**	1.24	**11**	1.34	**6**	1.48	**11**
8	APU Queens Building	1.75	**42**	2.42	**51**	2.75	**42**	3.08	**44**	1.52	**16**
11	John Cabot CTC	1.65	**36**	2.29	**45**	3.6	**65**	5.31	**92**	3.1	**91**
12	Rotherham Magistrates Court	3.71	**86**	4.21	**99**	4.1	**85**	4.75	**78**	2.86	**84**
13	Charities Aid Foundation	2.56	**69**	2.44	**55**	3.24	**56**	4.59	**73**	1.74	**33**
14	Elizabeth Fry Building	1.69	**38**	2.69	**61**	4.47	**92**	5.17	**89**	2.93	**86**
16	Marston Book Services	3.06	**75**	3.37	**82**	3.77	**71**	1.7	**13**	1.85	**45**
17	Co-operative Retail Services	1.33	**19**	1.46	**14**	1.8	**28**	2.41	**28**	1.5	**14**
18	The Portland Building	2.91	**74**	2.96	**70**	3.89	**75**	5.21	**91**	2.2	**64**
	Benchmark (1999)	2.25	**60**	2.43	**53**	2.86	**47**	51	**51**	2.08	**57**
	Scale midpoint	4	**87**	4	**93**	4	**80**	63	**63**	4	**99**
	All Probe average		**52**		**52**		**57**		**54**		**50**
	All non-Probe average		**48**		**47**		**47**		**48**		**48**

Notes to Figure 22

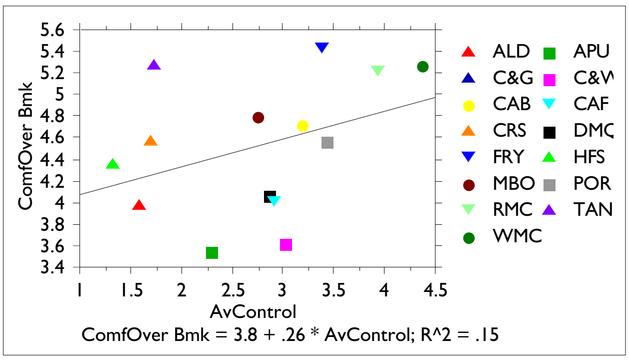
Variable names

CntHt	Control over heating
CntCo	Control over cooling
CntVt	Control over ventilation
CntLt	Control over lighting
CntNse	Control over noise
AvControl	Average of the five control variables

Variable scales

1=No control; 7=High control

Data not available for C&G.



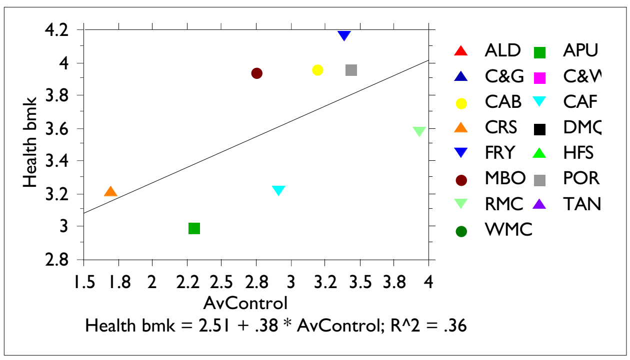


Figure 23: Probe buildings on quickness variables.

Scale: 1=not at all; 7=quickly	QuickHt		QuickCo		QuickVt		QuickLt		QuickNse		AvQuick	
	Mean	%ile	Mean	%ile	Mean	%ile	Mean	%ile	Mean	%ile	Mean	%ile
1 Tanfield House	3.5	**62**	3.6	**68**	3.7	**50**	4.1	**47**	3.2	**75**	3.6	**67**
2 1 Aldermanbury Square	3.2	**45**	3.1	**40**	3.0	**18**	3.8	**29**	2.6	**35**	3.1	**29**
3 Cheltenham and Gloucester	.	**.**	.	**.**	.	**.**	.	**.**	.	**.**	.	**.**
4 De Montfort Queens Building	2.8	**8**	3.3	**58**	3.9	**58**	4.7	**64**	2.0	**5**	3.3	**40**
5 Cable and Wireless	3.0	**22**	3.0	**27**	4.2	**78**	4.3	**50**	2.5	**28**	3.4	**47**
6 Woodhouse Medical Centre	4.8	**98**	4.0	**83**	4.5	**85**	5.6	**91**	3.7	**95**	4.5	**91**
7 HFS Gardner House	3.1	**38**	3.2	**53**	1.2	**2**	1.3	**2**	3.2	**78**	2.4	**2**
8 APU Queens Building	3.0	**32**	3.2	**53**	3.6	**42**	4.0	**41**	2.1	**8**	3.2	**36**
11 John Cabot CTC	3.4	**58**	3.1	**40**	4.1	**65**	5.6	**84**	3.6	**88**	3.9	**78**
12 Rotherham Magistrates Court	4.6	**95**	5.3	**98**	4.9	**92**	5.6	**88**	3.6	**92**	4.8	**98**
13 Charities Aid Foundation	3.6	**68**	3.6	**72**	4.2	**72**	5.2	**71**	2.5	**32**	3.8	**74**
14 Elizabeth Fry Building	3.3	**48**	4.0	**83**	4.8	**88**	5.5	**78**	3.5	**82**	4.2	**84**
16 Marston Book Services	3.9	**82**	4.0	**83**	4.2	**75**	2.9	**5**	2.6	**38**	3.5	**53**
17 Co-operative Retail Services	2.9	**18**	2.9	**22**	3.1	**25**	3.7	**19**	2.4	**22**	3.0	**16**
18 The Portland Building	3.7	**72**	3.4	**63**	4.3	**82**	5.6	**81**	2.8	**55**	4.0	**81**
Benchmark (1999)	3.38	**55**	3.4	**63**	3.67	**50**	4.41	**53**	2.8	**52**	3.5	**57**
Scale midpoint	4	**85**	4	**83**	4	**62**	4	**41**	4	**98**	4	**82**
All Probe average		**53**		**61**		**64**		**56**		**52**		
All non-Probe average		**45**		**41**		**44**		**51**		**48**		

Notes to Figure 23

Variable names

QuickHt Heating conditions achieved not at all/quickly

QuickCo Cooling conditions achieved not at all/quickly

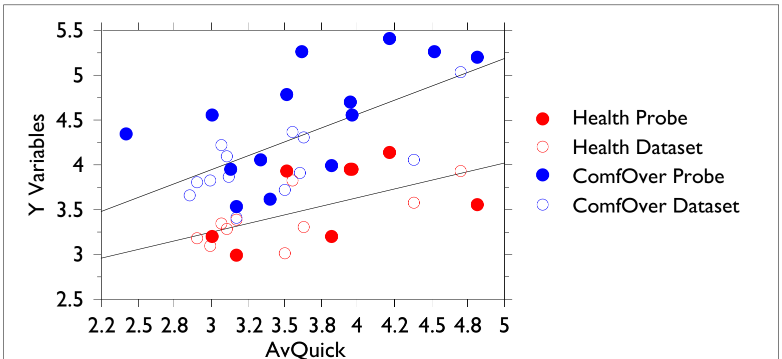
QuickVt Ventilation conditions achieved not at all/quickly

QuickLt Lighting conditions achieved not at all/quickly

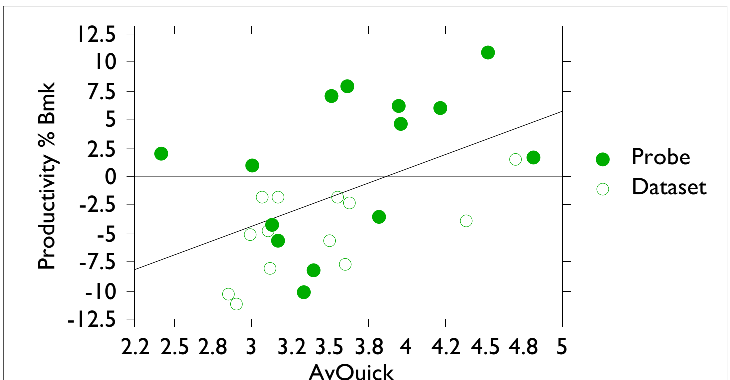
QuickNse Noise conditions achieved not at all/quickly

Variable scales

1=not at all; 7=quickly



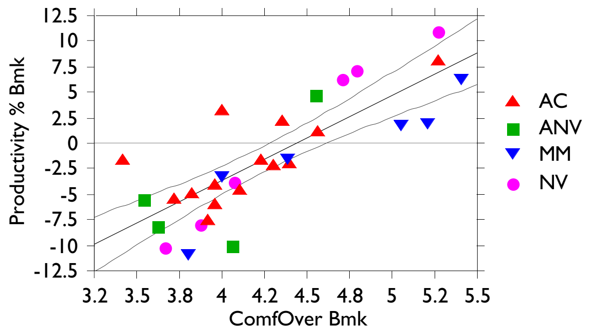
ComfOver Bmk = 2.09 + .62 * AvQuick; R^2 = .41
Health bmk = 2.09 + .39 * AvQuick; R^2 = .38



Productivity % Bmk = -19.37 + 5.01 * AvQuick; R^2 = .25

Figure 24: Probe buildings, perceived productivity and overall comfort:

1999 BUS Dataset



Productivity % Bmk = -37.21 + 8.39 * ComfOver Bmk; R^2 = .64

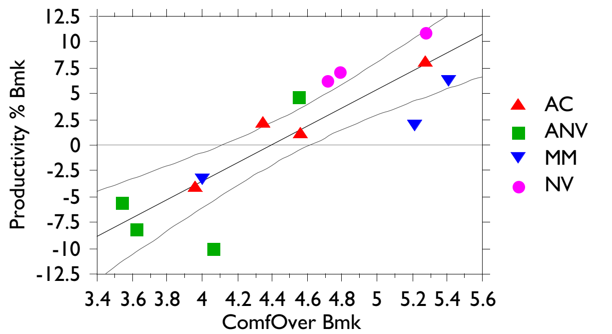
Notes to Figure 24

Variable names

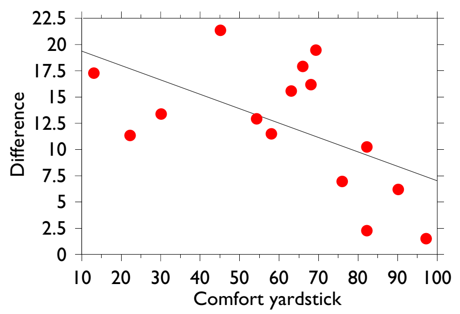
ComfOver Bench	Overall comfort benchmark
Productivity %	Perceived increase or decrease in productivity

This relationship is significant, p=<.0001 (see below).

Probe buildings



Productivity % Bmk = -39.01 + 8.89 * ComfOver Bmk; R^2 = .74



Difference = 20.68 - .14 * Comfort yardstick; R^2 = .31

Correlation Matrix

	Comfortyardstick	Difference
Comfortyardstick	1.00	-.56
Difference	-.56	1.00

15 observations were used in this computation.

% Productivity	**Dissatisfied with overall comfort**	**Satisfied or neutral with overall comfort**	**Difference** (col ii minus col i)	**BUS comfort yardstick**
	I	ii		%ile
TAN	2.3	8.6	6.3	90
ALD	-11.9	1.0	12.9	54
C&G	-7.1	3.2	10.3	82
DMQ	-23.3	-1.9	21.4	45
C&W	-18.3	-1.0	17.4	13
WMC	-13.3	6.2	19.5	69
HFS	-8.5	7.7	16.3	68
APU	-12.2	-0.8	11.4	22
CAB	-8.6	9.4	18.0	66
RMC	0.0	2.4	2.4	82
CAF	-13.2	0.1	13.4	30
FRY	5.0	6.6	1.6	97
MBO	1.4	8.5	7.0	76
CRS	-7.8	3.8	11.6	58
POR	-5.4	10.4	15.7	63
Average	-8.8	4.0	12.8	

Figure 26: Percentage frequency diagrams for Probe buildings for the overall comfort variable

Scale: 1=low, 7=high

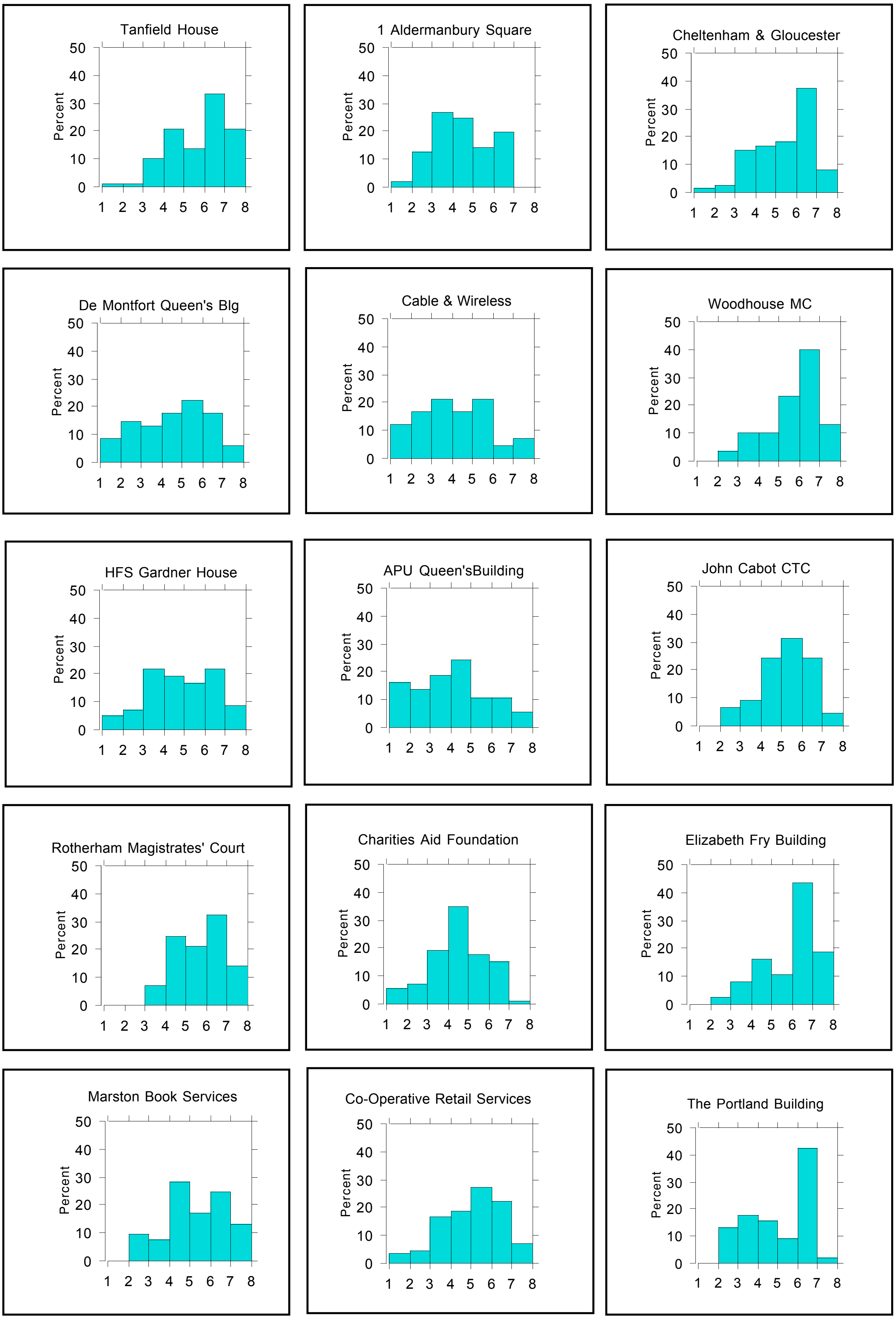


Figure 27: Productivity variable plotted with selected variances for Probe buildings

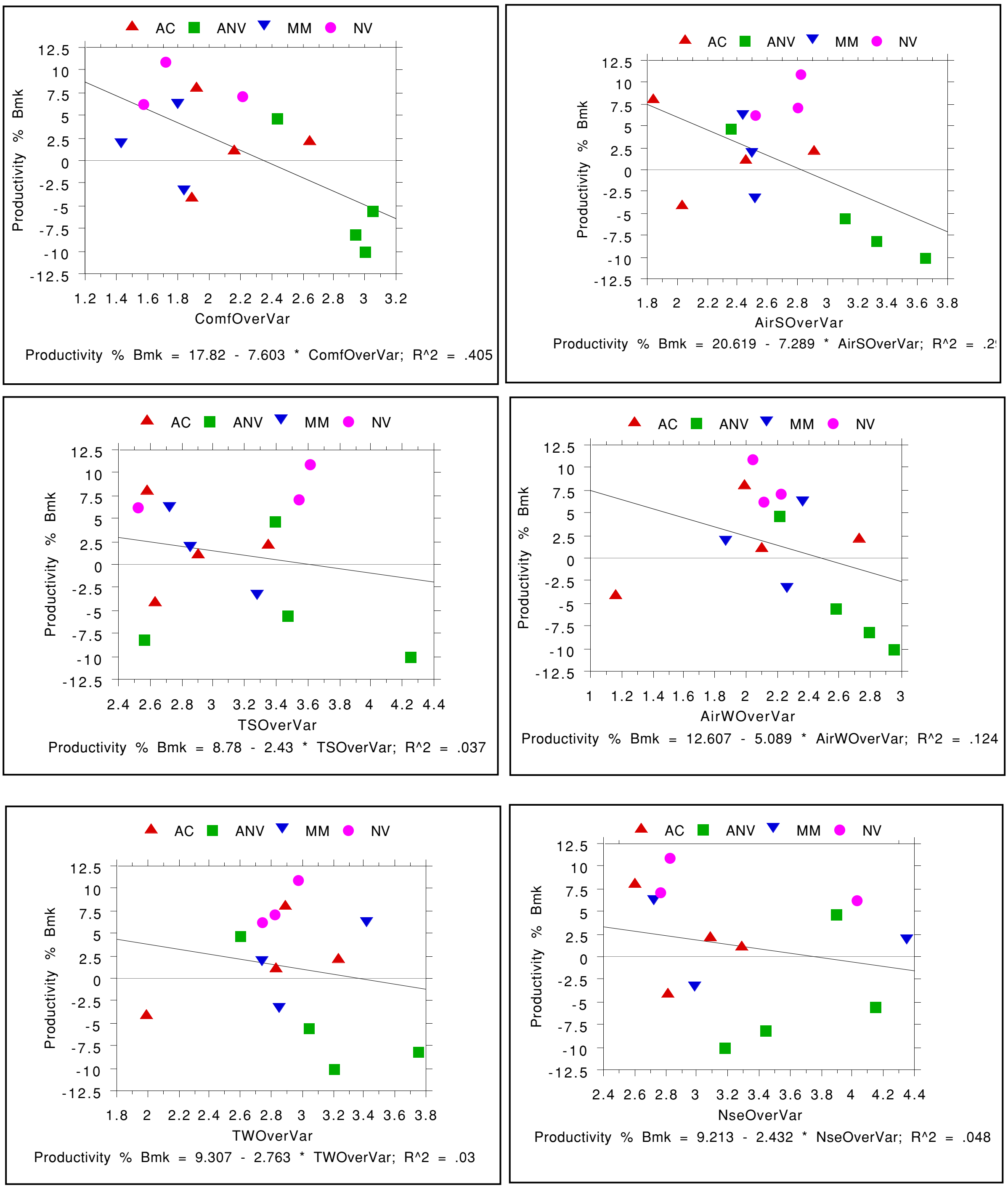


Figure 28: Productivity variable plotted with selected lighting variances for Probe buildings

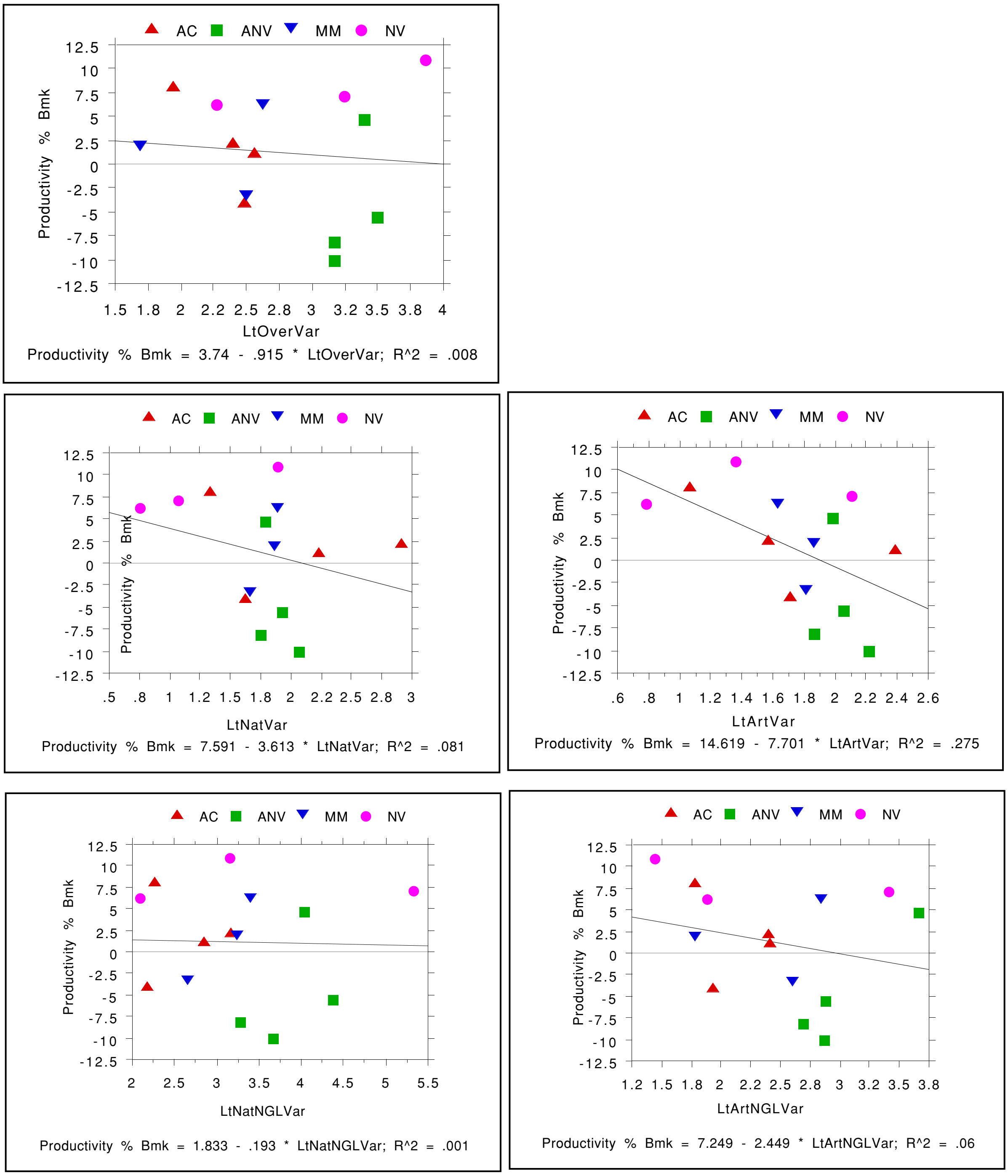


Figure 29: Quickness scores plotted against variance for overall comfort for Probe buildings

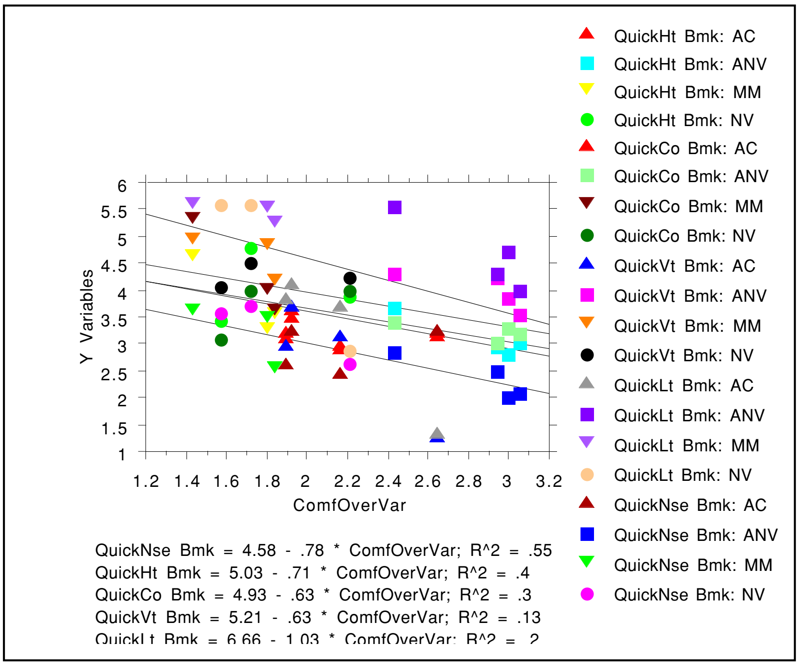


Figure 30: Control scores plotted against overall comfort variance for Probe buildings

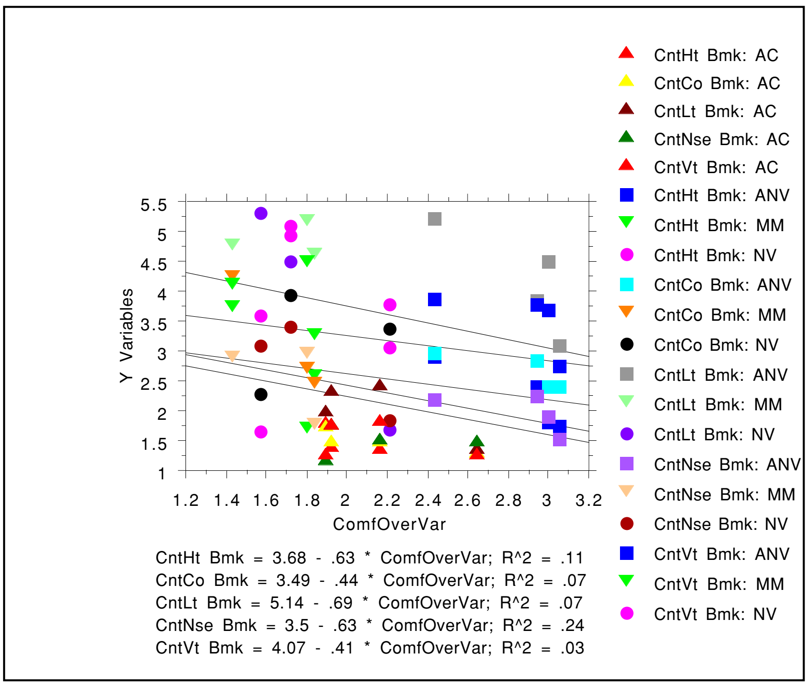
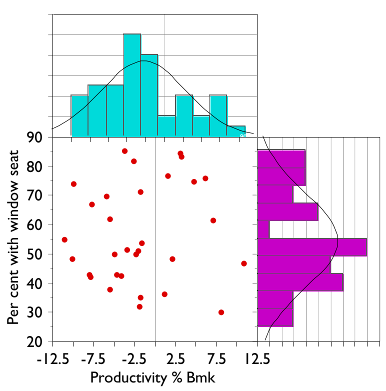


Figure 31: Further statistics about occupancy and use for Probe 2 buildings

Row	Staff (Probe #)	11 CAB	12 RMC	13 CAF	14 FRY	16 MBO	17 CRS	18 POR
1	Per cent with window seat	.	14	51	76	62	36	75
2	Per cent worked in building for less than one year	22	14	37	31	24	26	16
3	Per cent worked in work area for less than one year	.	.	66	53	62	58	20
4	Per cent working in building for 5 days a week	98	79	90	51	98	87	65
5	Per cent at desk for more than four hours a day	.	90	94	95	100	94	91
6	Per cent at VDU for more than four hours a day	20	68	86	79	85	86	51
7	Per cent dissatisfied with overall comfort	16	7	32	11	17	25	31
8	Per cent experiencing discomfort with at least one element	86	65	95	73	79	88	88
9	Per cent dissatisfied with speed of response	38	29	40	44	54	42	67
10	Per cent dissatisfied with effectiveness of response	39	43	60	30	54	45	62
11	Perceived productivity of uncomfortable staff	4.3	-1.8	-4.3	3.5	4.6	-0.8	0.9
12	Perceived productivity of comfortable staff	15.0	8.8	4.3	11.1	14.0	10.8	8.0
13	*Difference(comfortable minus uncomfortable)*	*10.7*	*10.5*	*8.6*	*7.6*	*9.5*	*11.6*	*7.1*
14	Percentage of staff scoring productivity as:							
15	Plus score	44	29	18	46	44	34	40
16	Neutral score	35	43	38	44	35	31	29
17	Minus score	21	29	44	10	21	34	31
18	*More pluses than minuses?*	*Yes*	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*
19								
20	Percentage of staff thinking that the building is more comfortable in …							
21	Summer	12	38	19	39	17	15	14
22	Equal	21	31	31	33	0	36	35
23	Winter	67	31	50	27	82	49	51
24	*Summer better than winter?*	*No*	*Yes*	*No*	*Yes*	*No*	*No*	*No*
25								

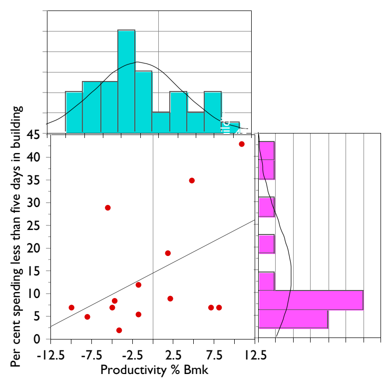
Row	Percentage of staff …	CAB Window seat Yes	No	*Total*	RMC Window seat Yes	No	*Total*	CAF Window seat Yes	No	*Total*	FRY Window seat Yes	No	*Total*	MBO Window seat Yes	No	*Total*	CRS Window seat Yes	No	*Total*	POR Window seat Yes	No	*Total*
28	Dissatisfied with comfort overall	.	.	.	.	.	.	15	17	33	6	3	8	8	4	12	7	18	25	20	11	32
29	Neutral/Satisfied	.	.	.	.	.	.	35	33	67	69	22	92	52	36	88	31	44	75	55	14	68
30	*Total*	.	.	.	.	.	.	50	50	100	75	25	100	60	40	100	38	62	100	75	25	100
31																						

Row	Perceived control over…	CAB Window seat Yes	No	RMC Window seat Yes	No	CAF Window seat Yes	No	FRY Window seat Yes	No	MBO Window seat Yes	No	CRS Window seat Yes	No	POR Window seat Yes	No
34	Heating	.	.	.	.	3.5	1.6	1.5	2.3	3.4	2.5	1.5	1.3	3.5	1.2
35	Cooling	.	.	.	.	2.9	2	2.5	3.4	3.7	3.2	1.7	1.3	3.4	1.5
36	Lighting	.	.	.	.	4.9	4.3	5.3	5.0	1.9	1.6	2.6	2.3	5.8	3.7
37	Ventilation	.	.	.	.	3.8	2.6	4.9	3.9	4.0	3.4	2.3	1.5	4.5	2.0
38	Noise	.	.	.	.	1.9	1.5	2.8	3.5	2.0	1.8	1.7	1.4	2.4	1.8
39	*Average*	.	.	.	.	*3.4*	*2.4*	*3.4*	*3.6*	*3.0*	*2.5*	*2.0*	*1.6*	*3.9*	*2.0*
40	*Difference (yes minus no)*	.	.	.	.	*1.0*		*-0.2*		*0.5*		*0.4*		*1.9*	



	Productivity % Bmk	Per cent with window seat
Productivity % Bmk	1.00	.09
Per cent with window seat	.09	1.00

31 observations were used in this computation.
29 cases were omitted due to missing values.



	Productivity % Bmk	Per cent spending less than five days in …
Productivity % Bmk	1.00	.47
Per cent spending less than five days in …	.47	1.00

14 observations were used in this computation.
44 cases were omitted due to missing values.