The importance of response time

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What are the variables that we really need to worry about in architectural and services design? A year ago I would have said that depth of space was fundamental - the deeper you go, the more services you need, the most complex the building becomes, the harder it is to manage, and the greater the subsequent risk that things will go wrong. Now, having spent the past year studying how people use controls in buildings, I would say that response time is even more important than depth.

Response time is the time it takes for the building or the building's management system (which can be human or automated) to respond to requests for change made by building users. Building users can be individuals, working groups, departments and their representatives or the whole organisation (organisations are almost always hierarchical, so decisions affecting the building can come from different types of "users" at different levels in the organisation). Requests for change can be commonplace everyday activities like individuals turning lights on or off, adjusting the window blinds, using the radiator control valves or setting room thermostats; or they may be less frequent requests from working groups or departments for re-arranging furniture, network cabling or partitions, for instance. In our research [1], we have found that the faster the overall response times, the greater the likelihood that staff will be healthier, happier and more productive, and the higher the likelihood that the building will be energy efficient. Health, productivity, energy efficiency, and rapid response, in other words, are all linked.

The best buildings are those that not only keep the majority of people comfortable and support their work tasks efficiently and inconspicuously for most of the time, but also respond very rapidly when people need to make a change to their conditions. Generally speaking, buildings need to, first, keep as many people as comfortable as possible (that is remain within their individual tolerance thresholds) for as long as possible and, secondly, on the occasions when people do become uncomfortable, the building should deal with the circumstances quickly.

In our experience, many modern offices seem only to have been designed with the first in mind, not the second. They often work reasonably well only when people stay within comfort or performance bands. When these thresholds are breached, which is becoming increasingly common for the reasons explained below, the buildings do not respond properly, if at all, and consequences like thermal discomfort and occupant ill-health quickly follow.

One of the main reasons why thermal discomfort and ill-health in offices especially (although the general argument also applies to

[1] The observations in this article are drawn from two studies carried out by Building Use Studies: *The Office Environment Survey* (1985-87) and *User and Automated Controls and Management in Buildings* (1991-1993)..

Details may be found in S Wilson and A. Hedge, *The Office Environment Survey: A Study of Building Sickness*, Building Use Studies, London, (May 1987) and AKR Bromley, WT Bordass and A. Leaman, *Improved Utilisation of Building Management and Control Systems*, CIB/IEA Symposium on Energy Efficient Buildings, Stuttgart (9-11 March 1993).

(Both are obtainable from Building Use Studies: telephone 071 580 8848, fax 071 580 2749)

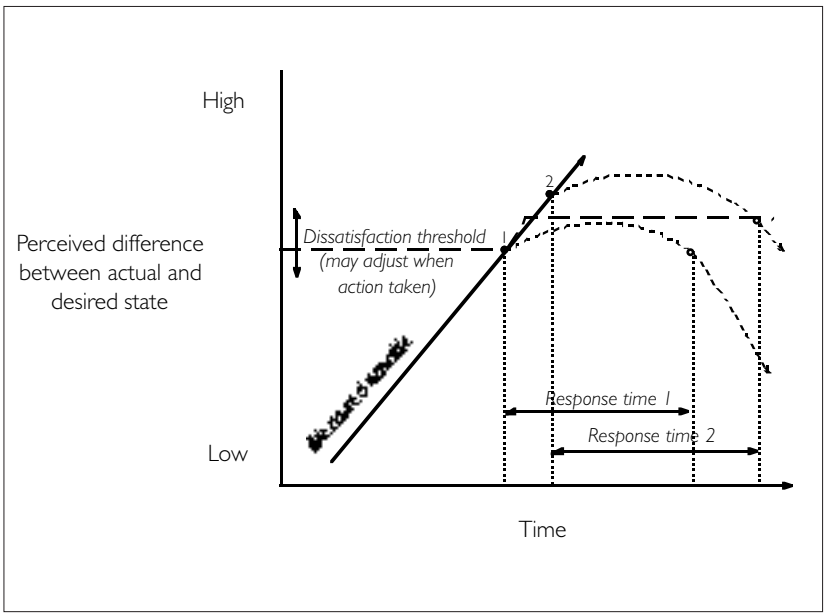
other building types) has increased in recent years is that the number of requests from users for changes to the conditions has gone up appreciably. Organisations are placing more demands on their buildings: they are using them more intensively over longer time periods for greater ranges of activities. Buildings are becoming more complex spatially, technically and behaviourally. All this adds up to a greater likelihood that more and more change requests will be made by the occupants.

The process is broadly illustrated in Figure 1. A measured variable, say temperature, gradually increases, but stays within the dissatisfaction threshold until point 1. At this juncture, the individual perceives discomfort and must decide "Do I act now to alleviate the discomfort or not?" Notice, by the way, that the setting of the threshold will vary for different people in different situations, and

Figure 1
Control behaviours and response times

Note that the measured variable may be analogue (like air temperature) or discontinuous (like glare or draught).

Figures 1 and 2 developed in discussion with Bill Bordass.



may adjust when the action is taken..

If the person decides to act, then they will look for the appropriate control device or system to assist them. This is the crucial moment. If the building systems can support the request and bring the measured variable back within the comfort threshold quickly, *and* the individual immediately perceives that the change has happened to their benefit, then they will probably be satisfied. A rapid perceived reaction may also help to widen the persons' tolerance threshold in the future, so that next time a request is considered the individual may delay action in the prior knowledge that the

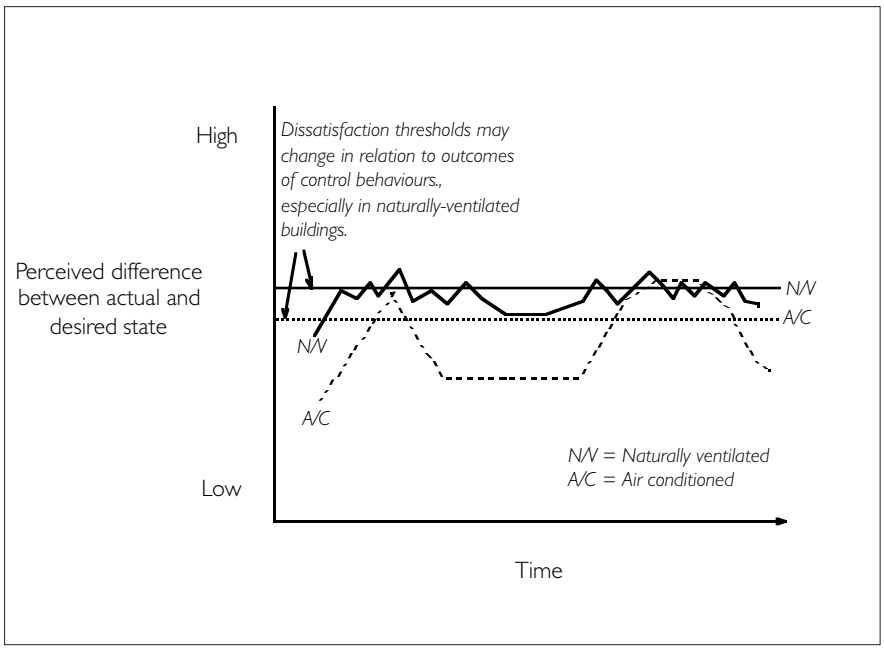
building systems can respond if needs be.

As long as the response is rapid and the individual thinks that a change has been made for the better, it does not really matter whether the system providing it is a physical system or a management system. This helps to explain why people often seem to prefer naturally-ventilated buildings to air-conditioned even though the measured conditions in air-conditioned buildings are often better.

A naturally-ventilated building will breach the dissatisfaction threshold more frequently, but its control systems (which are often simple and robust mechanical systems) will often quickly bring it back inside again. An air-conditioned building may run with a lower tolerance threshold and take a longer time to respond when conditions become uncomfortable. Although the air-conditioned building may be "better" in terms of the measured conditions, it runs for a longer period outside the dissatisfaction threshold compared with the naturally-ventilated building (see Figure 2) and so is perceived as being more uncomfortable overall.

These observations reinforce the points made by Nigel Oseland in an earlier article in *Building Services*. Theoretical predictions of thermal comfort derived from controlled conditions in comfort chambers seemingly over-predict temperatures that people find comfortable in reality. As our everyday experience tells us, comfort depends on contexts and circumstances. The reason why people

Figure 2
Control behaviours and response times in naturally-ventilated and air-conditioned office buildings.



seem to set temperatures lower at home than in the office is not because they are paying the bills, but because their naturally-ventilated homes are much more controllable. They can set the temperatures closer to their own preferences and the control systems act quicker when conditions do become uncomfortable . In the office, people must observe the norms and preferences of working groups and colleagues. Not only does this make decision-making more difficult if several people are involved, especially in open-plan areas, it also sacrifices the comfort of the majority to the wishes of a minority - the least comfortable or the most dominant personality, perhaps. It also takes longer for people to reach a decision, and longer for the system to adopt the new state once the decision is made.

Dealing with the full ramifications of these observations is beyond the scope of this article. [1] But there are some useful pointers emerging. Achieving rapid response in buildings is very important both for individual users and for building managers. Overall, the design strategy should be to *design for manageability,* because this will help to focus detailed thought on the areas of buildings which seem to have been most neglected - the control systems and their human interfaces. Taking this approach brings large benefits. People are happier with more responsive controls: they are more productive and healthier. Interestingly, also, buildings which work well for the people also are often energy efficient. The reason? The buildings are more manageable. It's as simple as that!

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[1] Rod

Please add an editor's note here that says: "Further details of the DOE/BRE project *User and Automated Controls and Management in Buildings* will be given in a forthcoming issue of *Building Services..*"