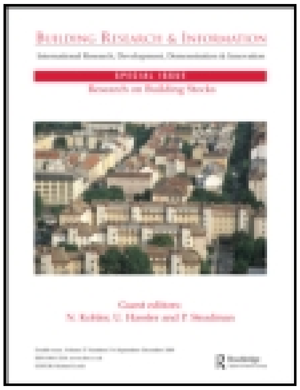

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Adaptive comfort

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EDITORIAL

Adaptive comfort

J. Fergus Nicol

The purpose of this special issue[1] is to present insights into some of the new thinking that is emerging about comfort in buildings, the directions in which it is developing, and the implications it has for the design of buildings and for the formulation of standards to guide the designer.

Over the last 10–15 years interest in adaptive comfort has increased enormously. Until the late 1990s it was an approach to comfort that was familiar to only a handful of academics and practitioners. A number of field studies had shown that existing approaches to comfort based on heat balance theory failed to explain the range of temperatures that people found comfortable in buildings with the variable indoor temperatures characteristic of naturally ventilated buildings.

An adaptive approach based on empirical field study results presents a solution to the problem. Against initial opposition, Richard de Dear and Gail Brager led a move to include an adaptive standard in the 2004 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) update of Standard 55 for use in naturally ventilated buildings. This led the way for the European standard EN 15251 in 2007 to include a similar adaptive section. There is now talk of an adaptive component to the next International Organization for Standardization (ISO) 7730 and a number of national and regional comfort standards. All major international standards will soon define acceptable temperature limits in buildings without mechanical cooling on the basis of results from comfort surveys in the field. There is little doubt that adaptive comfort is now part of the mainstream. Whilst this approach to setting standards, which relates acceptable indoor temperatures to the outdoor temperature, has clear advantages – it is simple in concept and accords well with people's understanding that the climate shapes our thermal preferences – there are also limits to its applicability. Nicol and Wilson address some of these concerns in their paper by providing a useful critique of EN 15251.

The adaptive model of comfort is based on the results of field surveys of people in their normal surroundings. The underlying assumption of the adaptive approach is that the thermal sense is part of the mechanism by which the body temperature is controlled. It becomes the driver for thermoregulatory behaviour as expressed in the adaptive principle: *If a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort*.

Richard Levins and Richard Lewontin make these telling observations in their *The Dialectical Biologist* (Cambridge, MA, 1985, p. 185):

> We share with other mammals the [physiological] mechanisms of temperature regulation. [...] But we also use clothing and shelter and burn fuel to warm and cool us. Th[is] has made it possible for our species to survive in almost all climates, but it has also created new kinds of vulnerability. Our body temperature now depends on the price of clothing or fuel, whether we control our [... heating system], whether we work indoors or outdoors, our freedom to avoid or leave places with stressful temperature regimes. [...] Thus our temperature regime is not a simple consequence of thermal needs but rather a product of social and economic conditions.

People who take part in field surveys are necessarily subject to the 'social and economic' conditions referred to by Levins and Lewontin.

People are not the passive recipients of the thermal environment as is often suggested by diagrams of the heat balance, but active participants in the interaction between the building and its inhabitants. Comfort becomes a *goal* which the individual will seek (Elizabeth Shove, *Comfort Cleanliness and Convenience*, Oxford, 2003) rather than a *product* provided by the building services (P. O. Fanger, *Thermal Comfort*, Copenhagen, 1970). This changes the rôle of buildings in the process from that of *providing* comfort to that of providing the *means* for building inhabitants to *achieve* their comfort goal.

The paper by de Dear revisits the work of Cabanac to show that adaptive behaviour is not simply about the negative avoidance of discomfort, but that responding to thermal variation can also bring positive delight. A significant hypothesis is presented about the

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perceptions of comfort as a complex interplay of sensations from temperature, air movement and other factors. This model may further the understanding and definition of the perception of comfort as a dynamic rather than a static process in the human body and could lead to new design specifications and performance metrics which embrace spatial and temporal dimensions.

An increasing number of buildings are mixed-mode or hybrid. The detailed mode of operation is extremely varied and is often also seen in terms of the energy sources they use: passive, renewable or conventional. In essence the adaptive approach makes no distinction between different types of ventilation. The differences lie in the effect the various ventilation approaches have on indoor environment. Given the opportunity, inhabitants will adapt to the environment with which they are presented. In a building where the indoor temperature is decoupled from the outdoor temperature, inhabitants' comfort temperature will also be decoupled. Where the two are related, then so too will be the comfort conditions. In hybrid buildings, then, the extent to which indoor comfort is 'adaptive' in terms of its relationship to outdoor temperature will depend on how the hybrid system controls the indoor temperature.

With a variety of possible indoor environments and modes of operation, the hybrid building could be expected to conform well to the model of an adaptive building being one which will enable inhabitants to find their comfort 'goal'. Borgeson and Brager show that mixed-mode buildings are indeed not only considered generally more comfortable by occupants, but also use much less energy than air-conditioning. Their approach considers the question of exceedance, which can help professionals (and standards) to address the comfort trade-offs in building design and operation.

A problem that arises is how to set the range of permissible temperatures around the optimum for any given outdoor condition. Insights into this problem are addressed by Zhang, Arens and Pasut, who find that although there are definite limits to the range of acceptable temperature and air quality in buildings, there is little advantage to be gained by fine-tuning the air temperature to an optimum provided that the temperature is within the permissible range. This range can be further extended by interventions such as adding air movement and radiation.

A challenge for researchers and designers is to make sense of conflicting behaviours and requirements to find ways to design buildings which use adaptive behaviour to achieve buildings which enable their inhabitants to make themselves comfortable and that also are sustainable. This shifts the focus of adaptive research from the precise prediction of indoor comfort temperatures and comfort zones to the detailed understanding of the adaptive process and of its form and its limits. This does not mean that standards become unnecessary, but that they need to be framed in a different way. A number of researchers have recognized this and some, such as Cândido, Lamberts, de Dear and Bittencourt, suggest that adaptive opportunity and the availability of adaptive behaviour should be built into standards. Surprisingly, no standards currently exist for the design of buildings using natural ventilation and the adaptive model. Their study proposes a set of guidelines for a future Brazilian standard (for the broad range of climates found in Brazil) focusing on naturally ventilated indoor environments, and taking into consideration thermal comfort, air movement acceptability and their interactions.

Adaptation makes sense of the way people use the controls they have (mechanical as well as non-mechanical). People act in a way that is rational to them – they are seeking comfort – but which may seem problematic to someone concerned with, for instance, saving energy. In addition people will almost certainly not behave in a precise or orderly manner. All sorts of factors will intervene because of social, economic or environmental pressures. Thus, when opening a window to cool a room, the feelings of others in the room, the wind outside or difficulties getting to the window to open it may all constrain behaviour. The window may even be opened before the room gets too hot in anticipation of overheating which would otherwise occur later in the day. So the act of window opening (which is a relatively clear response to overheating) is a stochastic process with an underlying order governed by the need to avoid discomfort.

Interesting insights into the way in which people conceptualize their relationship with buildings are given by Strengers and Maller, who deal with comfort as a factor in both supply- and demand-side energy considerations in a residential context. Residents' actions are shaped by their understanding of social, cultural and technical factors. The lack of a coordinated public policy response to cooling sends conflicting messages to people, and can lead to the unrestricted use of air-conditioning and runaway peak demand. So in addition to relevant standards and appropriate design, there is a pressing need to improve engagement with the demand side (inhabitants and occupants) at both the conceptual and practical levels.

Continuing the theme of a user-centred perspective, Moezzi and Goins focus on the workplace by analysing and interpreting the ways people use language to describe their experiences of the building. This gives insights into the factors that contribute to comfort and helps clarify the nature of adaptive interactions.

The findings are a reminder that comfort and satisfaction are derived from more than physical attributes and can also depend upon the operation and management of a facility. Understanding occupants' wider views about their workplace would be a wise prerequisite to optimizing their participation in adaptive comfort or a low-energy building.

The science of thermal comfort is itself a hybrid embodying physics, physiology, behaviour, meteorology and many other disciplines. However, the designer is an architect. The job of the scientist is to generalize from the particular evidence from experiments, surveys etc. using scientific dimensions such as temperature. The architect on the other hand takes all sorts of general insights (including hopefully some from science) and produces a particular object (a building). The components of architecture are walls, doors, windows, shades and so on. So the definition of a standard for buildings in terms of temperature, humidity and other essentially scientific dimensions adds a layer of confusion between the designer and the comfort of inhabitants. To help the architect to design comfortable and healthy buildings, standards will eventually need to use the insights of biology, physics, simulation and so on – and of adaptive comfort – to frame guidelines and appropriate modelling techniques in terms of the actual components of a real building and how best to assemble them.

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Endnote

[1]The papers in this special issue (with the exception of that by Strengers and Maller) were selected from the Windsor Conference, 'Adapting to Change, New Thinking in Comfort', held on 9–11 April 2010. The selected papers are expanded versions of the conference papers, have undergone a further double-blind refereeing process undertaken by the journal, and subsequent revisions by the authors.