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Civilising Comfort: 1914-1945

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Abstract

Climate's influence on social behaviour was one of the core beliefs of early twentieth century science. Many of the engineers and physiologists involved in the nascent development of thermal comfort studies made frequent reference to the writings of the geographer Ellsworth Huntington. Huntington considered that civilisation was ultimately determined by changes in climate. Yet, while it is well known that early indices of thermal comfort between 1920 and 1950 came out of research that sought to determine set points for mechanical equipment, what has been overlooked are claims made at the time about the links between civilisation and comfort. This paper is a first attempt to investigate the beliefs concerning links between climate, comfort and productivity contained in a number of the key texts on thermal comfort during this period. It proposes that initial misunderstandings came out of a desire to legitimise a new field and the imperatives of colonialism at this time.

Keywords: Climatic determinism, productivity, industrial hygiene

Introduction

The geographer Ellsworth Huntington (1876-1947) casts a long shadow over studies of the ideal environmental conditions for industrial efficiency. Current scholarship holds him up as a warning of the dangers of 'Meteorological Taylorism' (Fleming, 1998) and an example of how science is used to legitimate imperialism (Peet, 1985), yet within the field of thermal comfort studies the lasting influence of his ideas has largely been overlooked.

This is a pity, as we are still manipulating statistics to fit the belief that there exists a direct relationship between productivity and the thermal conditions of the workplace (Seppanen & Fisk, 2006) without any consideration of the cultural assumptions and the validity of the data behind them. It is not the aim of this paper to debate current claims, but rather to offer a number of historical perspectives on the relationship between the thermal environment and productivity.

In effect this is an exploration in how the field of thermal comfort studies tried to legitimise itself during the first part of the twentieth century and how thermal studies of mental and physical efficiency became a pretext for industrial reform, racial segregation and imperial settlement.

To understand this, it is necessary to first explore the political context in which geography and physiology were operating in. At the end of the nineteenth century, the ending of slavery in the USA and population growth in Europe and Asia saw the introduction of immigration restrictions, debates about racial productivity and an imperial search for land suitable for permanent settlement by Europeans.

The tropics were viewed as sites of physical and mental persecution (Arnold, 1996). To those who favoured European migration to the tropics, disease not climate was seen to be the primary handicap to long-term settlement. The question of acclimatisation was 'a medical conversation about health, disease, hygiene and the body' (Livingstone, 1999). In Australia, the physiological work of the Townsville Institute from 1910 allowed the Australasian Medical Congress in 1920 to declare on medical grounds that Northern Queensland was suitable 'for the successful implantation of a working white race' (Anderson, 2002, p.139).

Alison Bashford has highlighted within an Australian context how race-based nation building and citizen formation occurred at the same time as the state assumed responsibility for public health (Bashford, 2000, p.249). The infamous White Australia policy was introduced with the Immigration Restriction act in 1901, in the first year of federation. Bashford acknowledges her work forms part of a series of studies in the Australian, Canadian and American contexts "exploring a biopolitical health as deeply constitutive of modern racialized nation-building" (Bashford, 2006, p.67).

Around this time, the United States expanded its tropical horizons after the Spanish-American war with the assumption of political control of Puerto Rico, Guam, the Philippines and Cuba following the treaty of Paris in 1898. Hawaii also came under its control that year, while in 1903, America gained effective sovereignty over part of Panama for the construction of a canal through the isthmus.

The economic context for this expansion was highlighted by the American geographer Ellsworth Huntington, writing in 1914 about the 'Adaptability of the White Man to Tropical America' when he frames both tropical America and Africa as 'the richest unexploited regions in the world' (Huntington, 1914, p.185). Tropical Medicine's research on disease removed one barrier to the possibility of permanent European settlement in the tropics, yet it was research on working conditions within the metropole that reframed temperature as a determinant of productivity and ultimately, industrial civilisation.

The Climatic Geography of Productivity

In January 1915, the first in a series of articles by Ellsworth Huntington on the relationship between Civilisation and Climate was published by the liberal New York magazine, Harper's Monthly. Using the "observed experiences" of factory workers in Connecticut and military students at West Point and Annanapolis he sought to answer questions about how people's work was affected by the weather (Huntington, 1915).

Despite using only a few locations and simplistic and incomplete graphical analysis relating mean outdoor air temperature to industrial wages and student exam scores, Huntington believed he could answer what time of year people worked best at, whether "brain-work" was influenced similarly to physical work and whether a uniform or changeable climate was better for work.

Such information was not really about improving conditions for workers. '*For instance*', he proposed, '*we shall be able to determine in what parts of our country or of the world the greatest amount of either mental or physical work can be accomplished. We shall be able to measure the differences in the efficiency of labourers and other workers of various races, and shall use these differences as the basis for determining where factories, schools, or other institutions can most profitably be located. We shall find that certain climatic conditions which seem pleasant are in reality debilitating. And, above all, we shall discover exactly what conditions are most harmful in such places as the tropics. With this knowledge we shall go to work, not to change the climate, but to supply some sort of stimulus or other corrective which shall overcome the effects of the specific meteorological conditions which are proving most harmful.*' (Huntington, 1915, p. 233)

Even with this brief plan of action, it is clear that Ellsworth Huntington's ideas were a mixture of climatic determinism and scientific racism. Indeed his work highlights the ongoing debate within geography and physiology about whether race or place was a better determinant of productive capacity.

Huntington was a quiet, intense man who struggled against university administrators during his time undertaking a doctorate at Harvard (1902-1907) and teaching geology at Yale (1907-1915). Though his early published work such as *The Pulse of Asia* (1907) was well received by the popular press, questions about the rigour of his methods and basic knowledge of the field began to emerge within academia. Twice, his request for a professorship was refused, causing him to part ways with Yale. As one of his referees for promotion, Albrecht Peck, Professor at the University of Berlin noted:

'I value Dr. Huntington as a very able and productive scholar and I shall be glad if he makes further contributions. But I must confess that sometimes his thoughts run ahead of the facts. He works more with a vital scientific imagination than with a critical faculty. This is a fact which is true of many of the young and eager men and in time, this quality will emerge' (Penck, 1912 in Martin, 1973, p.86).

Though, Huntington's laxity may have been a product of his youth, the influence of his early work was wide, necessitating a study of how he went about fitting facts to his vital imaginings.

Towards the end of his tenure, he travelled throughout Latin America and the Bahamas and worked up a manuscript that would become one of his most influential works, 'Civilization and Climate'. Harper's Magazine agreed to serialise a number of the chapters and the book was published by Yale University Press in 1915 and revised and updated in 1922 and 1924. Looking at two of his most important diagrams from that book, one relating "Mean Temperature and Vital Processes in Plants, Animals and Man" (Figure 1) and the other showing "The Distribution of Energy on the Basis of Climat (sic)"(Figure 2), a concern for graphic clarity overrides attention to data.

The first figure is the basis for claims of an optimum mean outdoor air temperature of 38 °F (3 °C) for mental work and an optimum of 60 °F (16 °C) for physical work. As published in book form, no explanation is given as to how the curves for mental or physical efficiency were derived. We must return to the magazine article to be told that they were based on the wages of factory operatives in Connecticut and student exam scores in Annanopolis and West Point. Huntington simply found the average exam scores and wages and plotted this against mean outdoor temperature.

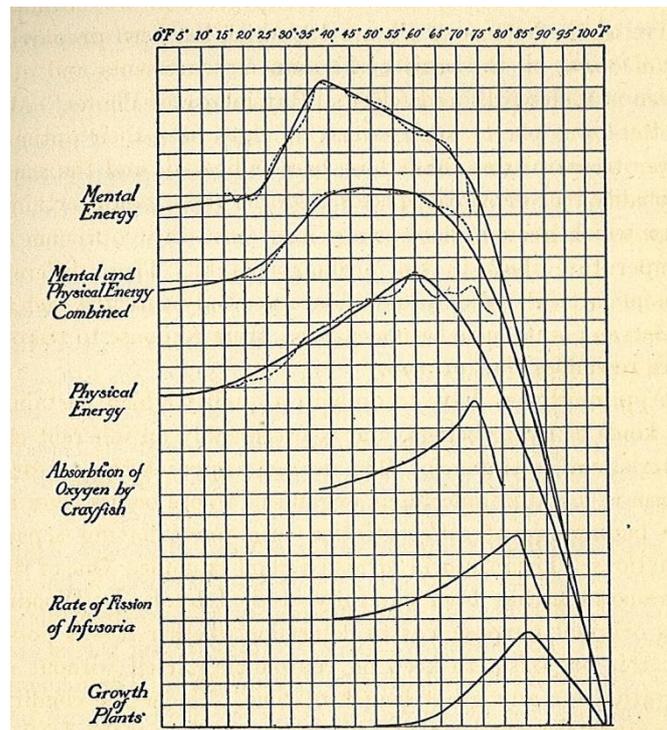


Figure 1: Mean Temperature and Vital Processes in Plants, Animals and Man (Huntington, 1915a, p.105)

Leaving aside the neutrality of wages and exam scores as tests of human efficiency, or any consideration of social influences in the workplace, Huntington's use of temperature statistics was reckless. The grid in the above diagram is meaningless as the curves are arranged to start at the mid-point of the text and bizarrely trend to the bottom right hand corner. He did not investigate the internal temperature (of any kind) of the factories nor was he concerned that records for the students were found only between mid October to early April, omitting the hottest days of the year. Instead he

blithely combined the curves for mental and physical 'efficiency' into a single curve '*representing man's actual productive activity in the things that make for a high civilization*'. As for the 'vital processes' of plants and animals, '*the resemblance of the human curves*' he continued, '*to those of the lower organisms is obvious. In general, the lower types of life, or the lower forms of activity, seem to reach their optima at higher temperatures than do the more advanced types and the more lofty functions such as mentality*' (Huntington, 1915a, p.109).

Having decided on the optimum temperature for human energy, he could move on to determine how it was distributed across the globe. The difference between his ideal 'mental' temperature of 38 °F (3 °C) and ideal 'physical' temperature of 60 °F (16 °C) troubled him. Although he could have gone half-way and proposed an annual mean temperature of 50°F (10 °C), "*southwestern Ireland with a range from 45° to 59° and the Hebrides from 42° to 55° would be more ideal than London.*" Instead, the Irish question was settled climatologically. A better solution, he argued, was to consider the winter mean temperature for mental activity and the summer mean temperature for physical activity. Humidity was a secondary factor, further evidence of 'harm' done to Ireland and western Scotland unlike England's 'climatic excellence'.

The 'evidence' of factory workers' records suggested changes in daily temperature could stimulate productivity. The problem for Huntington was that, yet again, his data did not correspond to the places around the world he considered most climatically favourable. By considering both the *seasonal* change of temperature and the number of cyclonic storms he believed he could then evaluate the relative stimulating effect of changes in daily temperature. He based his theory of climatic stimulation on exchanges with Charles Kullmer, Professor of German at Syracuse University. Kullmer proposed that shifts in storm tracks corresponded to shifts in the locations of civilisations (Martin, 1973, p. 103).

Finally, Huntington had settled on three variables: the mean monthly temperature, the daily temperature range and the relative humidity. The only problem was that he only had global information on mean monthly temperature, no quantitative figures for humidity and limited information on changes in daily temperature. But sure of the conceptual basis of his theory, he pressed on with his plan to construct a map of climatic energy.

Despite his previous rhetoric about the cold being ideal for 'more lofty functions', Huntington used only the 'warmer' physical efficiency curves to assess the stimulating effect of mean monthly temperature. He then approximated daily temperature change in a convoluted procedure that combined the weighted seasonal difference of mean monthly temperature with the weighted average number of storms per year.

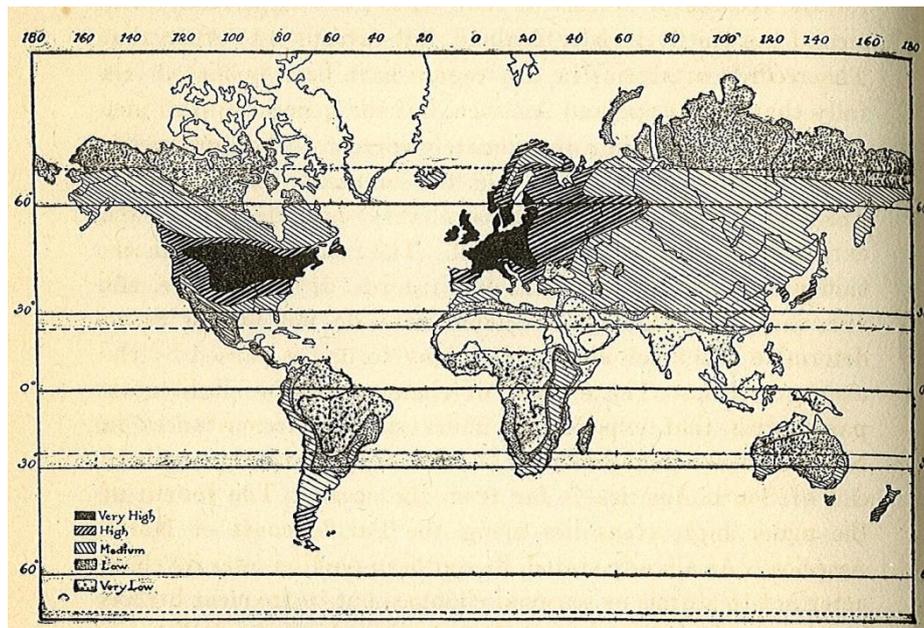


Figure 2: The Distribution of Energy on the Basis of Climat (sic)
(Huntington, 1915a, p. 142)

The map naturalised the industrial world as the appropriate location for civilisation. How else could it, when methods were based on the British climate as ideal. It also played up the prominence of East Coast America, Huntington's home, and diminished the importance of Asia, to his apparent surprise. When Huntington argued that civilisation was related to climate, he received angry letters from southern gentlemen, while the Japanese geographer, Ogasawara Kazuo would later adjust the map to give Japan the same prominence as its imperial rivals (Martin, 1973; Zaiki & Tsukahara, 2007).

The search for the ideal temperature

Arnold persuasively argues that tropical medicine's emergence at the turn of the century 'served both to celebrate Europe's growing sense of mastery over the tropics and the idea of tropical difference' (Arnold, 1996, p. 153) what is overlooked was the importance of industrial hygiene to tropical medicine's understanding of acclimatisation. Physiologists within the metropolis were studying the effects of extreme industrial environments on productivity. The similarities in temperature and humidity between these artificial environments and tropical climates was not lost on reformers such as Leonard Hill. Yet such work must also be viewed in the context of battles between management and staff between assumed ideal conditions for productivity and comfort in extreme working environments.

One major significant aspect of early research on internal environmental comfort lies in the conceptual development of temperature and subjective warmth. Early studies of the internal environment (1900-1930) were mostly concerned with the physiological limits of extreme working conditions. At the beginning of the century, J.B. Haldane showed the influence of high humidity on fatigue in hot atmospheres, but to Thomas Bedford, it was Leonard Hill's research from 1911 that completely reoriented the study of ventilation (Bedford, 1952). His studies of the relative effects of the chemical and physical properties of the air disproved the old theory that respiration of Carbon

Dioxide was responsible for discomfort. Instead he emphasised the 'skin effects' of the air: temperature, humidity and movement (Cooper, 1998). As Gail Cooper has so eloquently outlined, Hill's new physical theory of comfort challenged accepted notions of ventilation in the USA. It arrived just after the A.S.H.&V.E had managed to ensure the enactment of a new of 30 cuft/min ventilation standard for New York Schools. This new standard ensured that only costly mechanical ventilation, rather than open windows, would be sufficient to meet the new legislation. But with doubts about the perceived danger of 'crowd poison', it gave credence to open-air crusaders' push for school reform. The New York State Commission on Ventilation, was set up, headed by Charles-Edward Winslow to answer whether window or mechanical ventilation was best for learning (Cooper, 1998).

These were the first controlled experiments to measure subjective warmth following Hill's new physical theory of air. The commission studied young, clothed male subjects under three atmospheric conditions: 20°C (68.0°F) with 50% Relative Humidity, 24°C (75.2°F) also with 50% Relative Humidity and finally 29.5°C (86°F) at 80% Relative Humidity (Winslow & Herrington, 1949). The exhaustive experiments lead in the end to dismissal of claims of the superiority of mechanical ventilation for comfort and a recommendation of lower indoor temperatures (Hill & Campbell, 1925, p. 35) But they found no evidence that temperature rather than teaching produced better educational outcomes(Cooper, 1998).

Rather than fight the new physical theory of ventilation, the A.S.H.& V.E. started their own laboratory in Pittsburgh to study the interaction of air temperature, humidity and ventilation under controlled conditions. Houghten and Yaglou introduced a new index of warmth, the effective temperature, allowing an understanding of the equivalent warmth of any combination of air temperature, humidity and ventilation rate (Bedford, 1936; Houghten & Yaglou, 1923a, 1923b). Together with C.P. Yaglou's work at Harvard from 1925, they sought to establish credible standards of comfort for indoor conditions (Cooper, 1998).

While these American standards were based on laboratory experiments, the British understanding of comfort was based on direct observation of people in industrial conditions. The air temperature measured by the thermometer was no longer sufficient to indicate comfort. However, establishing an index of comfort proved controversial as instrumental readings correlated differently with sensations of warmth of subjects. Where the ASHVE simulated the air-conditioned indoor environment, Leonard Hill sought to simulate the skin. He developed the 'kata thermometer' to measure his concept of the 'cooling power' as the amount of heat lost from the skin.

The kata thermometer consisted of an alcohol thermometer, heated to 100 °F, with a graduated scale to allow the measurement of the time taken for the thermometer to drop by 5 °F. Covering the bulb of the thermometer with a muslin bag changed it to a wet kata thermometer. Hill was attempting to simulate heat loss by dry skin and wet skin and even proposed a 'clothed' kata thermometer to simulate the clothed body (Hambly & Bedford, 1921). Though the kata thermometer accounted for conduction, convection and radiant heat loss, it proved unwieldy in practice. Bedford later acknowledged problems with the oversensitivity of the kata thermometer to air movement (Bedford, 1936) while in his M.D. thesis, D.H.K. Lee cursed the instrument as he noted of his experiments in Singapore: '*A week's investigation of*

conditions in the Examination Hall of the King Edward VII College of Medicine at Singapore sorely tried the tempers of staff (Lee, 1940, p. 98).

In 1936, Bedford attempted to settle the differences between the various instrumental readings by testing ‘the reliability of various single measures of warmth in the environment as indices of warmth comfort’ (Bedford, 1936, p. 17) concluding that: ‘*with the exception of the reading of the globe thermometer, the equivalent temperature is a better measure of environmental warmth than any of the instrumental readings which have been discussed*’ (Bedford, 1936, p. 27). Both Bedford and Yaglou’s comfort zones would come to be a determining influence in explaining the ideal conditions for civilisation for both the geographer Sydney F. Markham and the physiologist D.H.K. Lee (Lee, 1940; Markham, 1942).

Climatic Reproduction

Although only ‘a first approximation of the truth’ (Huntington, 1915a, p. 141), research on the ideal climate for civilisation proved not only controversial, but a key reference during the inter-war years for many of the physiologists favouring the improvement of environmental conditions in factories and schools. Though Hill, Winslow and their French counterpart, André Missenard were mostly concerned with the relationship between the body and its industrial environment, they relied on Huntington to justify the importance of their work to a wider audience. Huntington gave respectability to claims that understanding and controlling temperature mattered and that their own work formed the basis for improving their own race.

Huntington was well aware of Hill and Winslow’s work. He was a colleague of Winslow at Yale and brought Hill’s experiments with the kata thermometer and his concerns about the indoor environment to the attention of geographers (Huntington, 1920). As Huntington and Griffith Taylor struggled to decide whether humidity or mean outdoor air temperature were better indicators of an ideal climate for settlement, a number of government committees in Britain were investigating the effects of humidity, air temperature and ventilation on fatigue in mines and munitions factories (Hill, 1916; Vernon, 1920). The ‘otherness’ of these artificial climates was not lost on investigators as they invoked tropical references to describe the conditions. Hill’s belief in the stimulating effects of the British climate mirrored Huntington’s, along with their shared fear of tropical environments. ‘*The ordinary indoor conditions of this country [England]*’, Hill worried, ‘*approximate to outdoor conditions in such a humid tropical climate as Ceylon, admittedly an enervating climate to Europeans*’ (Huntington, 1920).

Hill, Winslow, Missenard and Huntington were all more interested in climate as a stimulant than sedate comfort. The distrust of completely artificial environments is a theme of these physiologists whose work was based around direct observation of industrial conditions. Research by Winslow, Hill, Vernon and Bedford on the other hand was paid for by statutory commissions set up to investigate the most favourable conditions for work in different industries.

Hill lavishly gave over a full page of his book on Health and Environment to Huntington’s map of the distribution of human energy on the basis of climate. Graphically Huntington’s map seemed convincing. Stripped of any explanation of methodology, it could be reproduced to reinforce claims about the greater natural

efficiency of Northern European and American workers, that the prosperity of a place and health of a people depended on its climate. However, Hill felt that it required further investigation using a kata thermometer. Statistics by Huntington were used by Hill and Campbell to argue that 'wind is one of the factors that gives energy to the race', backing up their own earlier statement that 'it has been clearly demonstrated that moving air is a great stimulus to the body' (Hill & Campbell, 1925). The authors noted the limited areas outside of Western Europe and the United States with high efficiency backing their later contentions that 'the Western standard of efficiency cannot be maintained for long in many tropical countries' (Hill & Campbell, 1925, p. 96).

Universal Comfort

Though Hill and Campbell were convinced that Europeans could overcome tropical disease and even endure outdoor agricultural work, they still believed that permanent settlement was an impossibility. Rather than advocate a technological solution, '*to meet the conditions*' they argued '*a virile fully-adapted race can no doubt be evolved slowly by natural selection of survivors, and by inter-breeding, e.g. a cross between Mongol or Amer-Indian and European is said to produce the most virile types*' (Hill & Campbell, 1925, p. 97). Their French counterpart, André Missenard, was even more concerned. Best known for his concept of 'resultant temperature' (Bedford, 1936; McIntyre, 1980), Missenard published a series of three books concerning man's relationship to climate. Heavily indebted to theories of eugenics, racism and climatic determinism, the work remains untranslated and is rarely referred to in the English speaking world. Though an engineer himself, he strongly resisted the advent of air-conditioning. He argued that people, specifically '*les civilisés*', were being put in more unfavourable climates causing a loss of their adaptive faculties. Missenard translated Huntington's maps from 'Civilization and Climate' for a French audience, using them to argue for climate as a controlling factor in the adaptation of race to place (Missenard, 1940).

Yet while Huntington sought to naturalise the industrial world, Missenard considered that the quest for comfort was causing a loss of the body's ability to adapt to its surroundings. Where he believed that civilisation was changing the relationship between man and his environment, it was not for the better. The way he saw it, such a civilisation required the body to be at rest to be intellectually productive or remain within a particular temperature range to operate machinery. However, the lack of heavy physical work by people, he believed, meant that they were no longer able to deal with sharp changes in metabolism and that the constant temperature of the work place suppressed people's adaptive efforts for most of the day (Missenard, 1937).

Air-conditioning was recognised, even by those who mistrusted it, as a possible corrective to enable the settlement of Europeans in their colonies. As Missenard argued: '*the heredity of the white man does not permit him for example to support with impunity, the climate of the tropics; there he loses, not only his physical qualities, but also his moral character, and the artificial climates ought to be able to limit the pain.*' (Missenard, 1937, p. vi).

But such technological fixes was also interpreted as a sign that virile Europeans were going soft in the colonies. Following the introduction of a cool room in Calcutta in 1924, the London Morning Post reported:

'But what would the men who fought at Marathon say about this central cooling? What would the men who defeated swarthy hordes and crossed plains and rivers and scaled mountains and founded empires, and, having performed these mighty feats, quenched their thirst in brandy concoctions and foaming English beer, what would these men think of the highly-paid officials and business men who must have a temperature of 65 ° F. before they can undertake the business of the day? Are even our proconsuls deteriorating? Can England hold India only in a temperature of 65 °F. ?'(Lee, 1935, p. 24).

The climatologist, Sydney Markham, developed Huntington's thesis that changes in civilisation were determined by changes in climate. He too considered that there was an optimum mean temperature that encouraged the development of civilisation. Basing his data for ideal temperature on the mean of Yaglou and Bedford's research, he argued that the increasing control of climate had allowed for the development of Northern European civilisation. But he saw the advent of cheap air-conditioning as a turning point in history. Bringing forth theories of race and place he preached that *'we are on the eve of developments greater than those of the past, for air-conditioning, and electrical development of many forms, will give man not only greater control of damp and cold, but of heat and dryness, and whilst the desert may not yet blossom as the rose, it may blossom once again with keen alert minds'* (Markham, 1942, p. 133).

Conclusion

By end of the Second World War, racial theories of social organisation and productivity were no longer credible and climatic determinism was seen as an embarrassment to the established field of geography. Huntington still serves as a warning of the dangers of Cargo-Cult science and the ease with which graphical data may be manipulated to fit initial hypotheses. Yet it is the enthusiastic reproduction of his maps that highlights the dominance of his theory on early thermal comfort studies and the ease of making a new field appear credible.

The attempts to integrate research into the effects of the thermal environment on human physiology were compounded by the way the concepts in each field were manipulated and misunderstood to perpetuate the existing social order. Beliefs that social behaviour and intelligence had a physical or genetic basis, profoundly shaped the way problems were formulated.

Yet the debates about indices of temperature and sensations of warmth show how concepts of thermal sensation came to be standardised and operationalised. The increasing rigour of experiments and field studies gave greater certainty in the measurement of theoretical concepts of temperature and understanding of physiological acclimatisation.

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