108: The analysis of the role of office space architectural design on occupant physical activity

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Abstract

This research work raises the issue that the design of the office environment layout may influence positively or negatively workers trip probability over the course of a typical day at work. A retrospective analysis of data collection that took place at the AT& T Laboratory in 2001 – 2002 in Cambridge has shown that each space has a particular value based on its popularity, defined by the number of trips that the occupant makes to the office destination. The motivational impact of occupant physical activity is being studied and special vocabulary has been designed to describe the types of activity and the reason why a trip may be initiated or influenced. The five month study at the AT&T Laboratory that measures spatial occupancy seeks to identify how this has formed habits. Based on preliminary research and the analysed data, this paper goes on to show that the daily total activity in office hours has the potential to increase, by increasing spatial attractiveness. It also addresses the question of how significant this could be to the occupants' health and fitness.

Keywords: indoor environment, occupant, architectural influence, physical activity

1. Introduction

Enhancing architectural design to support physical activity serves prioritised approach to increase population levels of physical activity and public health in EU, US research [1]. Public health researchers and practitioners are currently working on social, physical, organisational and political ways that can promote physical activity behaviour. Several recent studies related to urban design and transportation have highlighted environmental characteristics (regional or community) that are associated with physical activity, such as the importance of the minimisation of the sprawl [2], the increased walkability and the accessibility to different locations.

Additionally, despite the two decades of research and objectives to increase physical activity, trends in leisure time physical activity are reported to remain the same in the US [3] with also no equivalent data being particularly encouraging in EU and abroad. Although a few studies have simultaneously assessed perceived and objectively measured environmental factors that can be related to urban design, transportation or recreational physical activity [4], very little has been done to assess the impact of the office indoor environmental design on occupants' physical activity and enhanced health. The prevalence of chronic diseases and other adverse health conditions are medically associated with sedentary lifestyles that are related to the fact that occupants spend increasing amount of time sitting at their desks. 60% to 70% of the office users worldwide reporting to spend increasing amount of time per day within an indoor work environment [5]. Recent UK data confirms trends towards sedentary lifestyles in offices as an effect of job and personal preference as well as modes of work in the organization.

Historically the office design preconceptions have been to reduce the extra "unwanted" movement and time spent away from the workstation. Increasing the walking distance to office destinations, intensity (mainly through stair climbing) and duration of activities pinpoint specific architectural challenges of this research. It is hypothesized that the architectural design could act as a basis for influencing the engagement in increased physical activity over the working day.

Health experts' broadly conceptualise the physical activity guidelines as "a lifestyle or way of life that integrates physical activity into the daily routines with the goal of accumulating at least 30 minutes of activity each day" [6]. This activity is meant to apply to all individuals of all ages and is suggested to be *moderate* which is equivalent to brisk walking (approx. 3 or more metabolic equivalents [METs] e.g. the activity of stair climbing). Brisk walking has been medically shown to increase fitness; reduce body fat [7, 8], lower blood pressure [9], increase high-density lipoprotein (HDL) [10], and reduce risks of bone fracture [11]. It has also been associated with the prevention of the incidence of over 20 conditions and some chronic diseases such as colon cancer, diabetes type II, osteoporosis and coronary heart disease (N.I.C.E. Guidelines on Physical activity (2008) [NHS National Institute for Health and Clinical Excellence]). Although

brisk walking is a readily available activity (i.e., requires no special equipment or training) [12] , it is estimated that only about 36% of men and 24% of women in the U.K. meet public health recommendations for physical activity by walking [13].
This is an exploratory study of a data collected at the AT&T Laboratory, Keynes house (Fig. 1), Cambridge. The building is located in close proximity to the city centre facing Trumpington road, a central arterial road that links the city centre to the outskirts. It also overlooks a frontage partly given for bicycle parking and partly being green. The building layouts consisted of closely clustered cellular spaces.

Fig 1. Keynes House, Cambridge.

This study examines the association between objectively measured numbers of trips and distance to office destination. Physical activity and its characteristics have been measured on three floors of Keynes House. It sets out to identify habitual behaviour, daily routines and trends for space use and preference.

2. Study Design

2.1 Data Collection

In order to identify how the movement of individual occupants changes overtime and how it develops into daily habits, this study is based on a long term data collection that lasted five months and involved the total office population. The equipment used to objectively measure location and map occupants' movements inside the office layout is the Active Badge. The location tracking method implemented in this study is a system that provides a means of locating individuals within a building by determining the location of their Active Badge signals. The small device, which has been worn by personnel, transmits a unique ultra-sonic signal every 10 seconds. Each office within the building was equipped with one or more networked sensors which detected these transmissions. The location of the badge (and hence its wearer) could thus be determined on the basis of information provided by these sensors (see Fig. 2). [14]

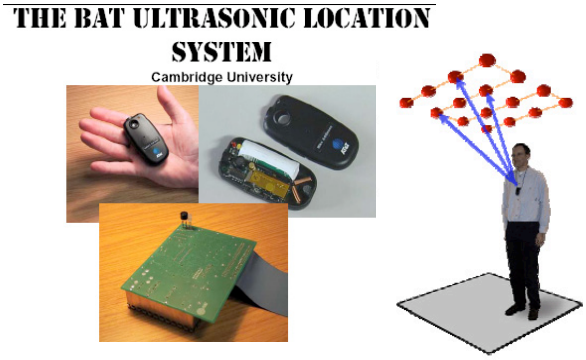


Fig 2. The Active Badge Ultrasonic location mapping system.

The selected spaces already hard wired with the Active Badge detectors. In this way the study and its analysis has been made possible. Issues related to the location tracking system unfortunately have not made possible the direct measurement of stair use in this building and have led to its inference from the route and the floor that a Badge wearer occupied every 10sec of an hour that the Badge transmitted a location signal.

2.2 Environmental measures

Occupants have been identified to initiate or extend walking trips voluntarily, or imperatively. In voluntary movement an alternative of not making a trip is provided, however, individuals choose to make it (e.g. go to the coffee station, to the print room, to a colleague's desk). In imperative movement an alternative of not making the trip is not really provided. An individual has to initiate or extend trips for office or physically generated reasons i.e. in order to meet the manager or visit the rest room. The initiation or not of a trip as well as the extension of one can be influenced by architectural qualities that are often perceived as rewarding for movement.
A reward can be visual; nutritional; social (stimulating social intercourse); functional (that can have imperative characteristics) and often combinations of two or more of the above mentioned. Trips to rewarding environments can also be initiated by the physical need to i.e. stretch the legs or by other psychological needs i.e. for a change of the sense of space, during the working day (activity often identified, through observations, to occur during lunch time, 12:50 – 13:30, and or around evening hours, 15:00 – 16:00). In some cases rewarding environments can even stimulate intense movement such as walking up and down the stairs. The reward in this case could be a large window on the staircase landings exposing the user to a view to the outside.
Direct observations as well as self reports have shown that the architectural provision for comfort and visual gratification can have a rather positive and rewarding effect on movement (e.g. walking up and down the stairs) but also a very negative effect on walking. Architectural attributes can dissuade movement by creating the sense of

common space and in this way minimising the sense of individuals' privacy. A window on a staircase landing that overlooks a part of a city that is not particularly pleasing to the eye seems to be persuading movement as it exposes an individual to a view to the outside. A staircase however located in the centre of an atrium space would dissuade movement as it has been reported to expose the individual this time to an environment of co- workers.

3. Output: analysis of results

The method of data collection that was implemented in this study has provided the following objectively measured data on the popularity and type of activity as well as the distance walked within the office to specific locations.

The sample of adults participating in this study was diverse with respect to age and race (ethnicity). The sample size was 327 participants with 56 wearing the Active Badge every day for a maximum of 5 days a week and for a total period of 5 months (November 7, 2001 – March 25, 2002). The rest of the participants were only occasionally using these office spaces (for a period of up to 15 days) during the whole of the monitoring period.

This study has been measuring habitual movement as it has been focusing on patterns of behaviour acquired through frequent repetition of trips registered by the Badges on all three building floors of Keynes House, AT&T Laboratory, Cambridge (Figure 3, 4, 5 below).

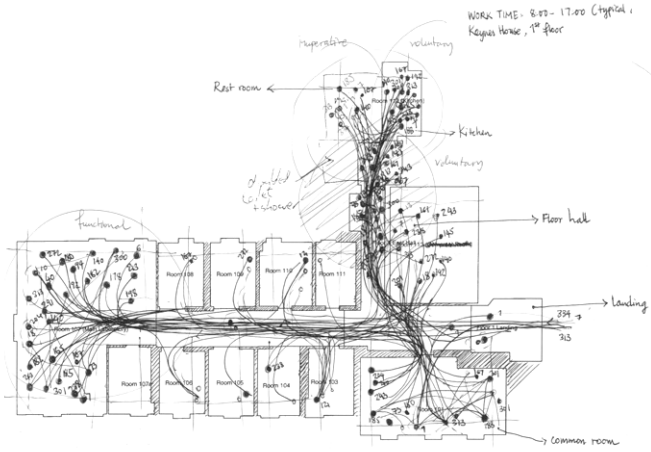


Fig 3. Flow map of occupants' patterns of behaviour on a typical 8 to 9 hr. day at work. Data acquired through frequent repetition of trips recorded by the location tracking device (Active Badge) on the 1st floor of Keynes House, AT&T Laboratory, Cambridge.

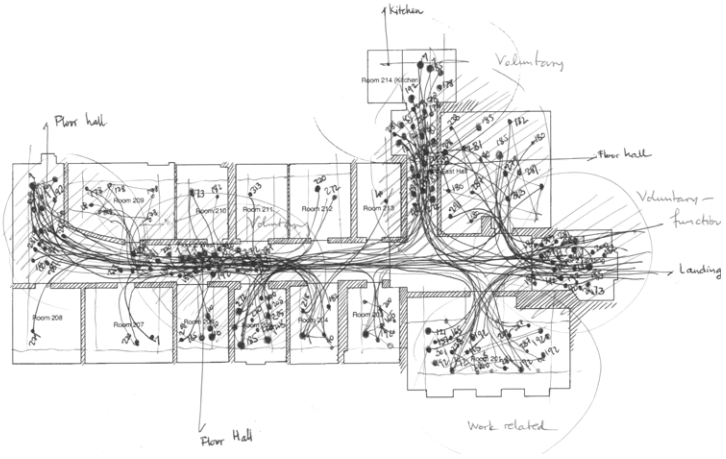
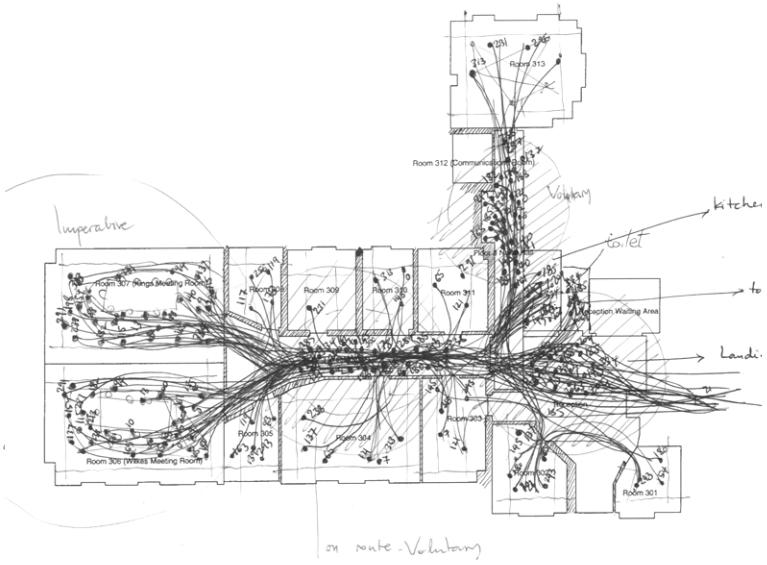


Fig 4. Flow map of occupants patterns of behaviour on a typical 8 to 9 hr. day at work. Data acquired through frequent repetition of trips recorded by the location tracking device (Active Badge) on the 2nd floor of Keynes House, AT&T Laboratory, Cambridge.

Fig 5. Flow map of occupants patterns of behaviour on a typical 8 to 9 hr. day at work. Data acquired through



frequent repetition of trips recorded by the location tracking device (Active Badge) on the 3rd floor of Keynes House, AT&T Laboratory, Cambridge.

At first glance the movement along the corridors to the floor halls and landings to the main laboratory and the meeting rooms appears to be a continuous one. A closer examination of the movements as they are registered by the badge reveals, however, that the corridors were not only utilised as routes to office destinations but in many cases as stations of en route trips. The need for informal communications has led occupants to walk approximately four times a day (Fig. 6: Floor Landing) to floor halls, staircase landings and the far end of corridors.

The high frequency of visits to the landing and reception areas indicates that informal communication mainly for job interaction is a predominant reason for movement.

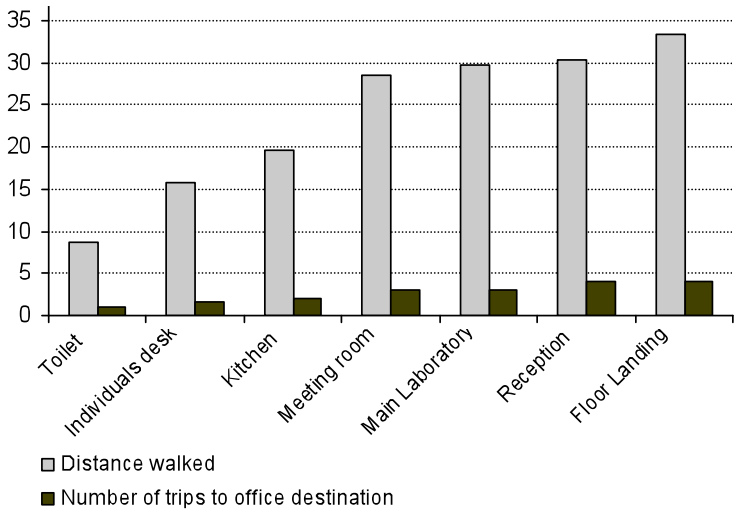


Fig 6. Average number of trips that one individual makes to an office destinations over a day at work and the total distance walked to this destination.

On a particular sample day (March 15, 2002) 7 out of 9 journeys that each individual made involved free choice for movement either for informal communication or for short recreation. Only 40% of the total movement over the day was made to places other than participants' own locations out of which 3% involved stair use. The energy expenditure for voluntary journeys to floor landings, to the kitchen or to other individuals' desks where calculated to be 5680J a day. The overall energy expenditure for office generated imperative trips involving stair use were 6467J over the day. No trip to the rest room involved stair use.

Occupants walked an average of 9.5 m. per trip to the rest room, 13.5 m. to the meeting room and 25 m. to any other voluntary trip destination.

Participants' resilience to make a trip can be represented by the relationship between the frequency of trips to a destination and the distance walked. We have identified in the overall 5 month data collection that free choice of movement has a negative and non-linear correlation with the distance walked to an office destination.

The element of choice can influence movement to specific locations of the building. The probability of a trip though is bound to a threshold of walking distance. Mean distance walked to the most popular space for movement, the landings, over a typical day at work has been 50m. If a floor landing was further than 75 m. from an occupant's initial location then the probability of a trip would be very low. Average distance walked over a day was 27m for walks to the reception, 10 m. to the main laboratory, 17m. to a meeting room, 35 m. to the kitchen, 25m. to a colleague's desk and 25m. to the rest room. Movement to almost all places no longer occurred if the distance from occupants' initial location was longer than 50m. The only reason why participants would walk up to 100m from the initial location would be to visit a colleague's desk. This was objectively measured (by the badge) to happen only scarcely due to the close clustering that characterised the management and occupation of the office space.

This study aims to identify ways to shift occupants' activity distribution to a higher level in order to ultimately increase the daily energy expenditure and thereby enhance occupants' health and fitness.

In this work also, it has been identified that the probability of an imperative trip is not affected by the distance. In other words, it has been observed and recorded by the Active Badge that occupants' movement curve to the meeting room or to the rest room does not take a declining effect as distance increases. In imperative trips the habit of making the trip becomes more ingrained and as it is not a matter of choice, occupants will walk to this destination wherever it may be within the office site. In seeking to promote physical activity through architectural design, we should think about the possibility of fixing the destination of the imperative trip (such as the meeting room or the rest room) in such a way as to make it possible to determine the levels of this activity from the design stage. In this case all individual's desk locations were designed to be approximately 20m. to 30 m. away from these rooms.

It has also finally been identified that voluntary trips can often have imperative incentives and characteristics.

4. Design implications

This study suggests that designing for imperative and therefore countable trips can have a positive effect on occupants' physical activity.

The resilience of making a voluntary trip can be affected by rewards for movement. Rewards involve different properties of routes and destinations which usually are combinations of stimuli, voluntary and imperative.

A building's stimulus can be synonymous to a point for visual gratification that could lead to stair climbing. Introducing or increasing stair use in everyday movement is suggested to potentially engender higher human energy expenditure and physical activity rates. This is because walking up and down the stairs has been shown to account for approximately three times the energy expenditure required for walking slowly on level ground [15].

Our preliminary assumption is that close clustering and direct proximity does not stimulate the additional physical activity required within the indoor office environment.

5. Discussion

In a rather unpredictable future of the newly changing and redesigned office where the ideas of energy conservation, time efficiency and flexible working are leading to new workplace design, it becomes evident that it is also uncertain whether physical activity levels will increase in the new office or not. Will flexible working, external meetings and incentive

schemes be the solution to consume less energy and expend more human energy? Certainly these schemes are set to have a beneficial effect on the organisational needs. It is suggested (NICE 2008) that many employers nowadays are increasingly recognising the value of health, and to recognise that by being physically active the mental wellbeing of their workforce can increase. Investing in health seems to be equivalent to benefiting their business by reducing sickness absenteeism and increasing loyalty and staff retention. This research adds to the above in the belief that architectural design can impact on occupants' physical activity and health.

6. Conclusion

There is some evidence that suggests that by designing for imperative trip destinations and by influencing the indoor architectural quality to reward for voluntary movement it might be possible to encourage occupants to accumulate significantly more physical activity during the work period. Increased stair use and reduced job clusters could also potentially help increase levels of activity indoors.

The goal of this research, based on objective measurements, is to develop an architectural vocabulary that will allow us to name and describe types of movements within office environments. This vocabulary could help assess the potential effect of indoor environmental layouts on occupants' movement and could further suggest to the architectural practice design methods that could ultimately stimulate physical activity and have a beneficial effect on overall public health and fitness.

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8. References

[1] U.S. Department of Health and Human Services. (2000) *'Healthy people 2010'*, Washington DC: U.S. Department of Health and Human Services.

[2] Ewing, R., Schmid, T., Killingsworth, R., Zlot, A. and Raudenbush, S. (2003) 'Relationship between urban sprawl and physical actiity, obesity, and morbidity', *American Journal of Health Promotion*, vol.18, pp. 47 – 57.

[3] Centers of Disease Control and Prevention (2001) 'Physical activity trends – United States, 1990 – 1998', *MMWR Morbidity Mortality Weekly Report*, vol. 50, pp. 166 – 169.

[4] Hoehner, C.M., Brennan Ramirez, L.K., Elliott, M.B., Handy, S. L. and Brownson, R.C. (2005) 'Perceived and Objective Environmental Measures and Physical Activity Among Urban Adults', *American Journal of Preventive Medicine*, vol.28, no.2S2, pp. 105 – 116.

[5]Andersen, B.P., Carson, W.E., Crespin, T.R., Emery, C.E., Farrar, W.B., Golden-Kreutz, M.D., Glaser, R. and Shapiro, C.L. (2004) "Psychological, Behavioral, and Immune Changes after a Psychological Intervention: A Clinical Trial", *Journal of Clinical Oncology,* vol. 22, no. 17, September, pp. 3570-3580.

[6] Orleans, C., Kraft, M., Marx, J. and McGinnis, J. (2003) 'Why are some neighborhoods active and others not? Charting a new course for research on the policy and environmental determinants of physical activity', *Annals of Behavioral Medicine*, vol. 25, pp. 77 – 79.

[7] Bond, B. J., Perry, A.C., Parker, L., Robinson, A. and Burnett, K. (2002) 'Dose-response effect of walking exercise on weight loss. How much is enough?', *International Journal of Obesity Related Metabolic Disorders*, vol. 26, no. 11, pp. 1484-1493.

[8] Slentz, C.A., Aiken, L.B., Houmard, J.A., Bales, C.W., Johnson, J.L. and Tanner, C.J., et al. (2005) 'Inactivity, exercise, and visceral fat. STRRIDE: a randomized, controlled study of exercise intensity and amount.', *Journal of Applied Physiology*, vol. 99, no. 4, pp. 1613-1618.

[9] Dunn, A.L., Marcus, B.H., Kampert, J.B., Garcia, M.E., Kohl, H.W. 3rd and Blair, S.N. (1999) 'Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial.' *JAMA*, vol. 281,no. 4, 1999, 327-34.

[10] Kelly, G.A, Kelly, K.S. and Tran, Z. (2005) 'Walking and Non-HDL-C in adults: a meta-analysis of randomized controlled trials.', *Preventive Cardiology*, vol. 8, no. 2, pp. 102- 107.

[11] Feskanich, D., Willett, W. and Colditz, G. (2002) "Walking and leisure-time activity and risk of hip fracture in postmenopausal women.", *JAMA* , vol. 288, no. 18, pp. 2300- 2306.

[12] Hillsdon, M., Thorogood, M., Anstiss, T. and Morris, J. (1995) 'Randomised controlled trials of physical activity promotion in free living populations: a review.', *Journal of Epidemiology and Community Health*, vol.49, No. 5, pp. 448-453.

[13] Rafferty, A.P., Reeves, M.J., McGee, H.B. and Pivarnik, J.M. (2002) 'Physical activity patterns among walkers and compliance with public health recommendations.', *Medicine & Science in Sports & Exercise*, vol. 34, no. 8, pp. 1255- 1261.

[14]The Active Badge System [online], Available:http://www.cl.cam.ac.uk/research/dtg/attarchive/ab.html [15 Jun 2007].

[15] Rowett Research Institute (1992) "Energy Expenditure", *Improving Food Quality & Preventing Disease: Fact Sheet 1*.