Designing an adaptive salutogenic care environment

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Biography

Cathy Dalton is PhD candidate at the Cork Centre for Architectural Education, Cork, Ireland, where she is researching potential uses of ambient technologies in healthcare environments for elderly people, as part of the NEMBES embedded technologies project. She is a graduate of UCD. Her professional background as an architect includes 17 years as principal in Dalton + O'Donnell Architects, where she was involved in the design and procurement of both day-care and residential care facilities for users with physical and mental disability and more recently, step-down care facilities for elderly people. She has a long-term interest in universal/ accessible design, and was part of the team, which won the People's Choice award at the NDA/ CEUD 24-hour Universal Design Challenge in Dublin last November, organised jointly with the Helen Hamlyn institute. She currently lectures in Professional Practice & Management at CCAE. Evidence-based healthcare design and use of colour in healthcare environments are areas of particular interest, both through practice and research.

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Abstract

Humans are profoundly affected by the surroundings which they inhabit. Environmental psychologists have produced numerous credible theories describing optimal human environments, based on the concept of congruence or "fit".[1 2] Lack of person/environment fit can lead to stress-related illness and lack of psychosocial well-being.[3] Conversely, appropriately designed environments can promote wellness[4], or "salutogenesis".[5] Increasingly, research in the area of Evidence-Based Design, largely concentrated in the area of healthcare architecture, has tended to bear out these theories.[6]

Patients and long-term care residents, because of injury, illness or physical/ cognitive impairment, are less likely to be able to intervene to modify their immediate environment, unless this is designed specifically to facilitate their particular needs. In the context of care settings, detailed design of personal space therefore takes on enormous significance.

MyRoom conceptualises a personalisable room, utilising sensoring and networked computing to enable the environment to respond directly and continuously to the occupant. Bio-signals collected and relayed to the system will actuate application(s) intended to positively influence user well-being. Drawing on the evidence base in relation to therapeutic design interventions,[7] real-time changes in ambient lighting, colour, image, etc. respond continuously to the user's physiological state, optimising congruence. Based on research evidence, consideration is also given to development of an application which uses natural images.[8] It is envisaged that actuation will require machine-learning based on interpretation of data gathered by sensors; sensoring arrangements may vary depending on context and end-user. Such interventions aim to reduce inappropriate stress/ provide stimulation, supporting both instrumental and cognitive tasks.

Introduction

The idea that design and physical context can measurably affect user well-being has emerged over the past generation, underpinned both by theory in environmental psychology and other disciplines, and by emerging Evidence-Based Design research. The notion of *salutogenesis,* as described by Aaron Antonosky[9] is a key element of *MyRoom*. His model of health takes into consideration factors which promote and maintain an individual's wellbeing, rather than focusing solely on pathogenic factors as causes of disease. Antonosky's theory resulted from his observations of individuals who had maintained good mental health despite being subjected to extreme psychological stress. He observed that these individuals appeared to possess a strong *sense of coherence*[10]. An appropriate physical environment which supports person-environment fit, or "*congruence*" can contribute to a sense of coherence. Richard Neutra, who set out design principles for spaces for living in 'Survival by Design', based on application of biological and behavioural sciences, developed parallel concepts. It is now also well-recognised that stress is at the root cause of many illnesses, both psychological and physical, through its effects on the endocrine system. In the context of healthcare buildings, the relationship between design and health outcomes continues to be researched. [11]The concept of "salutogenic design" has been embraced in the area of healthcare design for obvious reasons: for example, certain aspects of design have been preventing to reduce patients stays and need for analgesia, and are therefore of interest to healthcare-providers. In the case of residential care for elderly people, the issue is not simply one of reducing patient stays, but of facilitating quality of life.

Theories of person-environment fit

Maslow's "hierarchy of human needs"(1943)[12] is possibly the best-known model of person-environment fit, and though it was developed in relation to the social environment, its principles may also be applied to the built environment.

Maslow's Hierarchy of Human Needs

Biologist Stephen Boyden, viewing human needs from an evolutionary perspective, distinguishes between "survival" and "well-being" needs", or functional and psychological congruence[13], the latter relating to fulfilment and psychological health. He defines the "biological determinants of optimum health" as "the conditions which tend to promote of permit an animal optimal physiological, mental and social performance in its natural evolutionary environment."[14] . These needs correspond well with those described in Maslow's hierarchy. To provide (or design) health-promoting environments for human beings, Boyden maintains that one must understand the complex set of relationships which have evolved over time between human beings and the settings in which they live. He perceives a frequent mismatch between our evolutionary environment and modern, industrialized environments. The same comment might be applied to institutionalised healthcare environments.

Functional congruence is a measure of how well an environment facilitates instrumental tasks, i.e. does the setting provide sufficient spec for the task in question? Is the space suitable? Are there sufficient resources available and to hand to carry out the task? Are the ambient conditions comfortable? Is there sufficient stimulation? Or is there too much stimulation (e.g. an overly noisy environment may impact negatively on performance of cognitive tasks) ref. may *Psychosocial congruence*, on the other hand, is concerned with how well an environment facilitates psychological and social well-being: is there space for rest and relaxation, opportunities for personalisation, a room/ space of one's own? Are there opportunities to socialise in an appropriate setting, as well as privacy when needed?

Similarly, Spivak, in his theory of archetypal space (1969) proposes that people function best when their environments afford places consistent with basic behavioural and emotional needs.

Kaplan emphasises the cognitive compatibility of the environment as a fundamental need, compatible environments being characterized by the presence of important resources, such as controllability and information, and the absences of attributes that are inconsistent with optimal perception and cognitive functioning, for example, distractions, excessive stimulation, confusion[15]. He also addresses a significant concern which had not been adequately addressed in person-environment congruence theory: is the absence of stressors alone enough to produce a sense of well being, or does well-being depend on the presence of different types of environmental stimuli and attributes?

Boyden also refers to a need for meaningful change and sensory variability, and an interesting visual environment that includes aesthetic integrity[16]. Such environments can support the need for knowledge and understanding. But in many contemporary care environments concerns regarding safety take precedence, with the hierarchical Maslow model being used as justification. Safety regulation may be subjected to such a narrow interpretation that it presents barriers to the provision of an environment that is psychosocially supportive, by restricting the options available to the designer. Aesthetic and design options become artificially narrowed by restrictions on use of materials, details, design features. Safety concerns have been prioritised to the extent that they actually damage the capacity care environment adequately addressing psychological and other higher needs. Nowhere is this more apparent than in the realisation of care environments for the elderly. Organisational culture can therefore not only influence the level and form of care provided, but also the physical context of the care setting.

It is important to remember that while it is vital that basic needs, such as survival and comfort, are provided for, there are other needs, which Maslow considers to be of lesser importance, but which must also be catered for in any healthcare setting that purports to be patient-centred. In the hands of a good designer, it is possible to create an environment which is successful in terms of creating a home-like environment appropriate to the needs of a resident with dementia.

Where an environment fails to provide for basic survival needs, such as food or shelter, serious illness or death will result; this is fundamental. However, Boyden further theorises that lack of psycho-social congruence can lead to what he terms *"The Gray Life"*, of psychosocial maladjustment; of depression, aggression, and furthermore of stress-related physical illness[17]. The term is singularly and unfortunately apposite in describing the likely outcome of placing any humans, let alone vulnerable elderly people, in the environments which have come, until very recently, to typify the residential care setting for the elderly. Over-zealous implementation of regulation can restrict choice to the degree that it may contribute to physical stress, inappropriate cognitive load, and lack of stimulation. This may be through a combination of unsuitable environmental conditions and insensitive and regimented management systems, which often seem to go hand-in-hand. Considering that dementia is the single greatest factor likely to lead to the placing of an elderly person on residential care, the possibility that existing care environments might actually worsen dementia-related behaviours constitutes an appalling vista.

General needs vs. needs of specific user-groups

In short, humans possess general characteristics which can be used to formulate guidelines for the design of psychosocially supportive environments, though some adjustment may be needed with respect to the differences and needs of each individual, particular within an elderly or ill population, and necessarily more so in the case of users with cognitive impairment. However, it should not be forgotten that these differences are variables in the context of a set of basic common human needs. It has been used as a convenience, and still is, to assume that older people are somehow "different" to the rest of us, enabling us as a society to consign them to care settings with which a healthy individual would be likely to express extreme dissatisfaction. An unimpaired person might verbalise their dissatisfaction with a specific environment, e.g. "it's too dark"/ "the sun is in my eyes" /"there's nowhere for me to sit and talk" /"I'm bored". They might then make changes, by switching on a light/ closing a blind/ getting a chair/ initiating a conversation/ reading a book etc. If the immediate environment is sufficiently uncomfortable, an unimpaired person may ask someone else to assist, move to another room or simply leave. Most or all of these courses of action may be unavailable to a person with dementia, (PWD) or a critically-ill patient. Disturbed behaviours (DB) associated with dementia are now seen as meaningful expressions of needs that must be addressed; it is also immediately apparent how much the built environment can contribute, or not, to meeting the needs of a PWD. It must also be borne in mind that in healthcare settings, users may be restricted for much of the time to a single space, which must therefore attempt to meet all requirements for both physical and psychosocial congruence.

Healthcare buildings which are well-designed can therefore be considered the appropriate architectural response to basic shared human needs. Many of the design issues addressed in exemplars of good healthcare design therefore have application right across the healthcare spectrum. It is not the intention of the research that the technologies proposed to enable environmental adaptability should replace good design, but rather that the possibilities afforded through use of ambient technologies should reinforce its potential, or render it more accessible to specific user-groups. Such interventions have greatest potential in the case of acute care environments with critically-ill patients, or as an ongoing and adaptable support system for long-stay residents of care facilities who have restricted mobility and/ or cognitive impairment.

Design for Dementia

Dementia impairs cognitive functioning, including memory or reasoning, linguistic ability, mood, depth perception, and motor control, leading to repetitiveness, wandering, combativeness, confusion, and secondary "Disturbed" Behaviours (BDs). Perception of sequence of events may be distorted, leading to disorientation and confusion. A person with dementia may feel shame or anger, being aware of their inadequacies; many may worry about the future, may feel confused and vulnerable and, perhaps most significantly, they will have trouble communicating their needs or feelings. Ultimately there may be fragmentation of one's very self. Current care models, as described by Gadow[18], aim to prevent the loss of the person to the disease; in other words, they aspire to being therapeutic.

Design of care settings for elderly people must inevitably address the issue of designing for the specific needs of persons with cognitive impairment. Loss of function and independence associated with dementia-related cognitive function is often the marker for a move to residential care: very many older people in care have some form of dementia[19]. In the US, in 2008, 45-67% of elderly people in assisted living and 68% of elderly people in nursing homes have some form of cognitive impairment, 47% with a diagnosis of dementia[20]. These impairments affect an individual's ability to interpret the environment, often in addition to loss of physical function, including mobility, visual acuity, or hearing, resulting from the ageing process. The capacity of influence environment to influence functioning of elderly people is well-researched.[21] For a person with dementia, many mundane tasks are rendered difficult by cognitive impairment; the built environment itself may further exacerbate this effect, if not carefully considered. Is it impossible to speculate that, given the range of technologies available today, things could be improved through making the person's individual environment capable of responding to their changing needs, even when they may not be able to articulate what it is that is needed, or intervene directly themselves? Do sensoring and wireless technologies present an opportunity facilitate a better physical and psychosocial fit? Might they go some way to alleviate issues such as an inability to effectively communicate one's physical or psychosocial status on the part of the user, or often co-existing physical impairment, which renders use of conventional environmental controls difficult or even impossible?

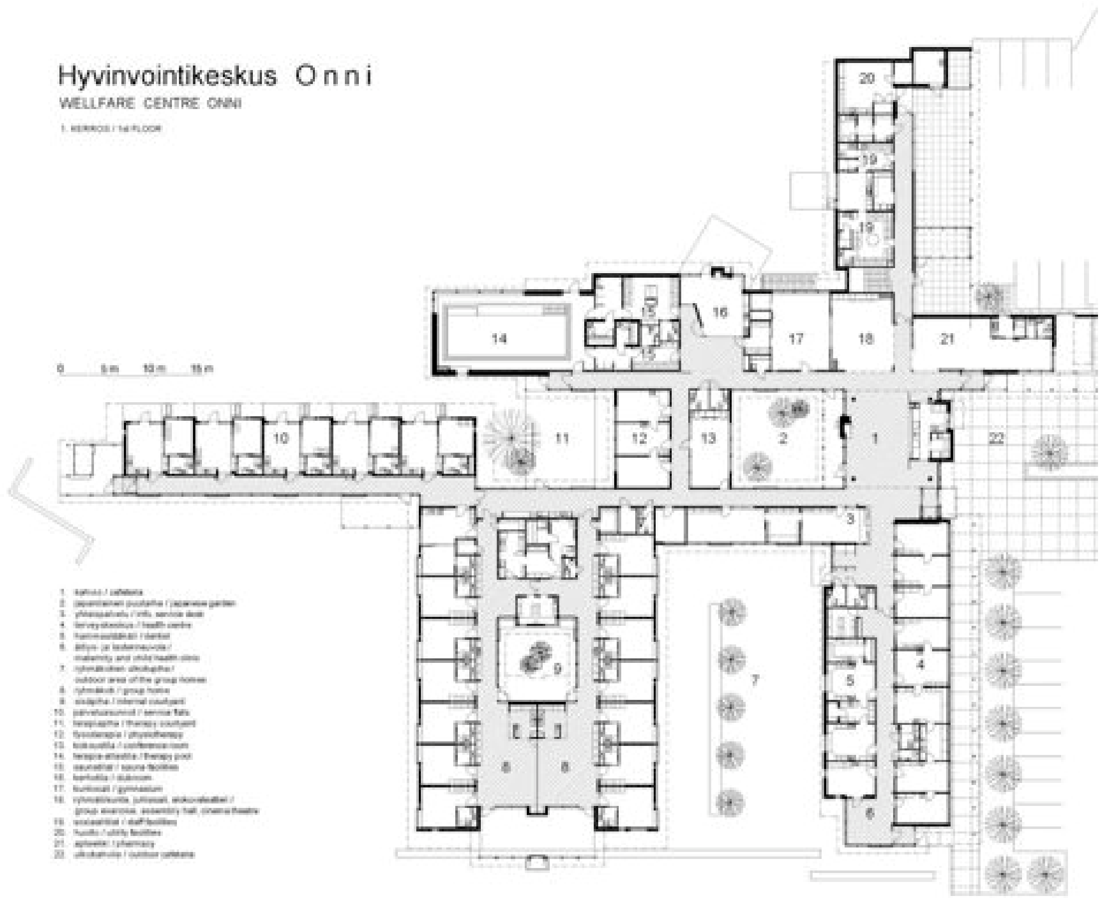
Similarly, design of an acute care environment must address the specific needs of the user who is temporarily incapacitated or immobilised, and in all likelihood extremely stressed by the illness itself, and the removal from a familiar environment. In either scenario, ability of the user to adjust the physical environment to achieve a high degree of "congruence" has decreased, temporarily or permanently. While good design facilitates functional and psycho-social congruence, assistive and prosthetic environments enabled by ambient technologies and pervasive computing have potential to further enhance the effects of good design by addressing the changing deficit in fit brought about by a user's changing needs, or varying environmental circumstances. Embedded technologies also have the potential to enhance congruence where physical limitations of an existing setting act as a constraint.

Ageing-in-place

Concepts of "ageing-in-place" vary between the US and the UK. In the US it is generally taken to mean residing in a purpose-built community of older people, where support is provided at a level appropriate to the person's needs, until death, without the need to move to other accommodation for treatment/ palliative care. In the UK it infers ageing in one's own private, possibly lifetime residence. It must be recognised that the needs of all elderly persons will not be met through the implementation of the latter initiative, most specifically the needs of those with more advanced dementia who are also the most vulnerable. It is perhaps naïve to assume that a majority of older people will in future live, close to family supports, in suitable or readily-adaptable accommodation, in locations where mobility and access to transport is facilitated. Death of a family carer seriously hinders the possibility of continuing to age in place. People living alone with dementia are at higher risk of self-neglect, injury and institutionalisation.[22] Differing mortality rates between the sexes implies by extension that the longest-living are, and will continue to be female. This also calls into question the issue of gender conceptualization, which may apply to the development of care models. It is worthy of comment that a marked preference on the part of elderly people to age at home is likely to be the consequence of the huge inadequacy of traditional models of elderly care in meeting the needs of users. Disturbingly, a new report from the UK Alzheimer's society finds that a quarter of a million people with dementia are not being provided with adequate care and support to facilitate ageing-in-place. [23] So, while most people with dementia commence by living with it at home, a majority (two-thirds in the US) will end by living, and dying with dementia in a residential care setting.[24] A considerable amount of the argument of the UK (and Irish) ageing-in-place model seems to revolve around the cost to the state of providing residential care places for a rapidly-expanding population of older people with dementia, and the deferral of a move to care for as long as possible on that basis. The prime consideration should, of course, be the question of what constitutes an optimal standard of care for PWD, and in giving elderly people a real choice as to how they live out their years.

The Green House ®

The MyRoom model is therefore conceived as part of model for communal living based on recent trends in the United States and Europe. In the US, there has been a gradual progression from de-instutionalisation (as in the Eden Initiative), through quasi-domestic residential models such as the Evergreen Community and Meadowlark, with identifiable internal neighbourhoods, to third-generation facilities consisting of grouped stand-alone households of around ten residents, epitomised by the Green House®. New models of care focus on the needs of the resident, rather than carers, or traditional nursing models. The Green House concept furthermore embraces smart-home technologies; for example, in order minimize intrusion resulting from monitoring. Significantly, architecture is recognised as a driving force in culture replacement in care of the elderly. European models include Finnish communal residential architecture as exemplified by the work of Mikael Paatela. This model of care includes apartments and group homes, such as “Willa Viola” and the Willa Home in Tampere, and the “Onni” Care Centre at Pukkiila. Here, communal living is in apartments of 40-60 m^2 with living room, bedroom, kitchen and bathroom, but also with a shared sitting-room, dining-room, kitchen, service facilities and staff rooms. The Onni project incorporates day-care facilities, and community healthcare facilities.



“Onni” Welfare Centre: Plan

Use of sensoring to support person-environment fit

Sensoring in an intelligent environment aims to track both position and activities of an individual at any given time. There is considerable ongoing research of sensoring methods for elderly people, such as in the TRIL project (Technology Research for Independent Living). http://www.trilcentre.org/ The question is, what is to be done with all this data? The notion of going beyond monitoring and prevention (e.g. falls prevention through gait analysis in elderly people) has been mooted[25]. Machine-learning may be required to make meaningful use of sensoring data, by identifying patterns of movement and behaviour, and in order to distinguish data indicative of normal status from data which might be indicative of distress. Pervasive computing systems which relay information on the health status of an individual to a remote station in order to support ageing-in-place have been developed. These systems might also be used in residential care/ acute hospital contexts to support security without undue loss of privacy, which would go some way towards supporting psychosocial congruence.

Bio-signals which are monitored to indicate stress include heart-rate and galvanic skin response (GSR); stress may be indicative of unmet needs. Kinematic data is also considered to be bio-sensing if the sensors measure human movement. In the case of dementia, sensoring of kinematic data offers an inexpensive method to monitor movement patterns and activity levels over long periods without being constrained to any particular room. Cameras, unless they are to be completely and invisibly integrated into the building fabric, are likely to be perceived as intrusive and destructive of user privacy in a long-term residential setting. Motion sensors can be relatively easily concealed in ceiling and walls, and are inexpensive in comparison to camera-based motion analysis systems, which also constrain the area where the patient might be monitored. Such sensoring might ultimately be used in conjunction with floor pressure sensors, such as SmartFloor, developed for the AwareHome project[26]. Smartfloor is capable of identifying an individual from gait patterns.

However, elderly people have been found to resist wearing sensors, which may make an individual feel self-conscious.[27] In the case of persons with advanced dementia, (and therefore, likely to be in residential care) there is a significant likelihood or removal of or damage to the sensor on the part of the user. The sensor in the latter scenario is in itself likely to become a stressor, and therefore decrease person-environment fit. There are two possible approaches: the first is to presume that increased miniaturisation and development of wearable sensoring will produce sensors which are unobtrusively small and/ or wearable. The second is to develop an approach where room sensors which use movement patterns/ kinematic data monitor an individual's status. Ideally, an intelligent environment will combine wearable /portable sensors to give a more comprehensive picture of a user's physical and psychosocial status on a real-time basis; this approach has been successfully used to monitor behaviour[28].

There are several of models and prototypes of intelligent domestic living-spaces for elderly people, including AwareHome[29], at Georgia Institute of Technology, US, http://awarehome.imtc.gatech.edu/ and Haus2 at the Fraunhofer Institute, Duisburg[30] www.inhaus-zemtrum.de. *MyRoom* might be incorporated into such environments, but is seen as being more appropriate for an assisted residential care context.

"Life-space" is also an interesting and relevant concept: elderly people at home often use far less of their physical environments than they are aware of; recent research has helped demonstrate this[31]. Shrinking life-space is also in accurate predictor both of a need for institutionalistaion and of early mortality. If this is the case, is the opposite true? If the environment of an elderly person can be rendered more adaptable to her needs, and more useable, can this assist in deferring a move to care? Can a move to an appropriately-designed environment, became appositive contribution to an individual's quality of life, if it facilitates functioning, including by taking advantage of the potential offered by use of ambient technologies, and allows life-space to grow again.

MyRoom Prototype

The idea of a therapeutic patient room is not in itself new[32], though the concept of enabling responsiveness to an individual user through use of sensoring is specific to *MyRoom*.

The complete prototype involves design and development of a single room with inbuilt sensoring and ambient technologies, which fully integrates multiple applications with the intention of supporting both functional and psycho-social congruence. Continuous real-time sensoring facilitates observation of an individual's activities, location and physical status. The research is part of the PRTLI-IV funded programme NEMBES, investigating the use of embedded technologies in the built environment. http:// www.nembes.org. As an architectural model, it is a fundamental prerequisite that sensors and actuators will be incorporated into the detailed design of the room to minimise negative effects on aesthetic qualities

The manner in which sensoring is carried out in order to gather data indicative of the user's psychophysiological state therefore may vary depending on context: a scenario for an adaptive room in an acute care context for a critically-ill patient might involve portable sensoring, measuring ECG, GSR, as some such data will already be monitored, and additional sensoring requirements readily addressed by modifying/ augmenting existing clinical equipment. This has been utilised in research into therapeutic use of music.[33]

In the research prototype, both wearable sensors and ceiling sensors will be used in the context of an individual room. While the prototype a spires to facilitate individualisation of the user's personal space, the model might also support maintaining an individual's independence within a care setting while affording some degree of privacy. The current "solution" is to constantly leave the doors of an individual's room open, in both acute or residential settings, or to rely, in acute settings, on a corridor-side observation window, which instantly guarantees an institutional appearance. A comprehensive intelligent room monitoring system might facilitate a "virtual observation window" which does not impinge on privacy.

It is hoped to initially rapid-prototype a single therapeutic visual application, supportive of psychosocial congruence, using the BioMOBIUS™ open platform, and Shimmer Research™ sensors, both developed by the TRIL project, prior to development and construction of a prototypical room utilising bespoke sensors, and ultimately integrating multiple applications. The initial application is envisaged as one component of this complete room prototype, the realisation of which is likely to involve collaborative postdoctoral research. Multiple responsive applications, controlling various environmental aspects, to include lighting and temperature, will be integrated into the model, thus supporting both functional and psychosocial congruence. Design of the prototype will be iterative, as various applications are integrated, and their interactions observed. This process mirrors the architectural design process.

A Therapeutic Visual Application

Despite popular assumptions, there is little scientifically conclusive research evidence to support the therapeutic properties of colour. The difficulty in establishing therapeutic benefit for colour may lie in the fact that experimentation has sought to attribute specific benefit for single colours. This might arguably be viewed as a simplistic model of how colour operates in the physical environment. Listening to music, on the other hand, has been demonstrated to be of therapeutic benefit in several experiments, including in reducing pain perception and need for analgesia.[34] Expecting physiological response to a single colour might well be likened to assuming that a single musical tone will produce any sort of psychophysiological effect. Few would assume this to be the case: listening to a musical *composition* is effective. To extend the musical/visual analogy: if a single note is the equivalent of a single colour, then a painting or static image may be the equivalent of a chord, while a video or film with continuously moving images might then be likened to piece of music. Colour in the architectural environment acts as one element of an aesthetic composition; it does not exist in isolation, even from other colours which simultaneously form part of the user's experience. The built environment does however afford the opportunity of using colour at a scale unachievable in other contexts. If there is specific benefit to be attributed to use of single colours, it is in the built environment that this is most likely occur. However, research methods to date have not facilitated testing at the scale of the room or architectural space. A room environment tends to be relatively static, wherein some changes may be made, such as turning on the light or rearranging the decoration. Walls may be painted a particular colour, but will stay that way for some time, until redecoration occurs. If the effect of colour on an individual is to be investigated, obviously a more flexible method of delivery must be provided. Similarly, different colours (or even combinations of colour) may prompt a range of reactions in people experiencing them, so that gross generalisations may result.

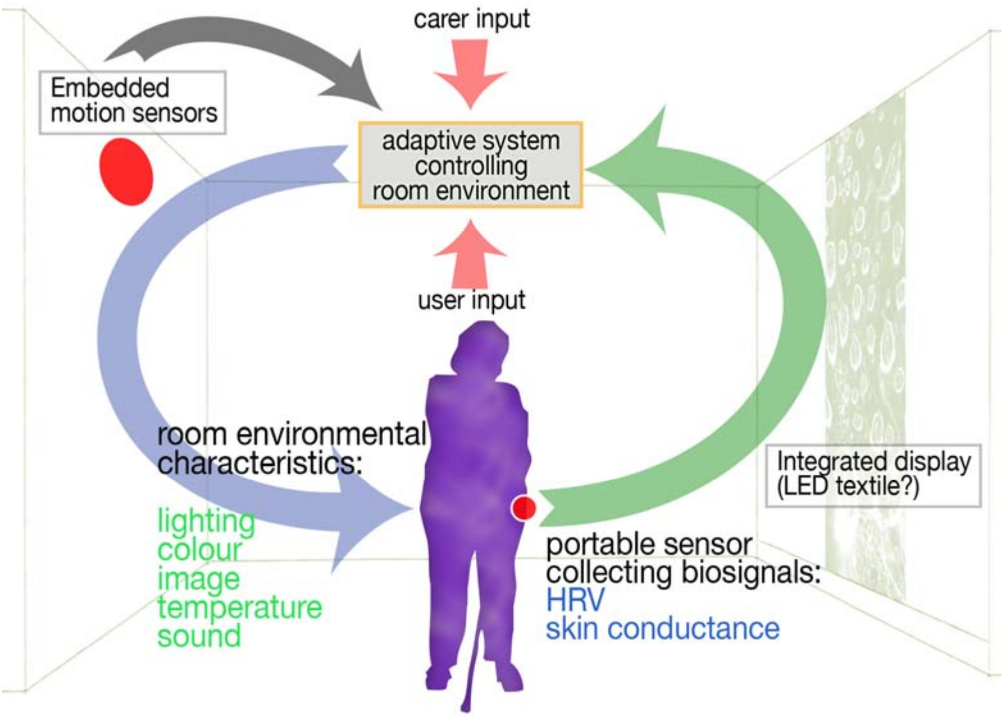
If we wish to elicit a positive (stress-reducing) response, in order to support psychosocial congruence, it is therefore reasonable to suggest that what must be tested is a composition of colours, be it abstract, figurative, or natural-occurring. Such an application also has potential to provide visual stimulation. Exposure to the natural environment, and even to images of it, can contribute to psychosocial restoration, and specifically to alleviation of stress.[35] As stress is pathogenic, use of such images to mitigate stress in healthcare and other settings has also been investigated. On this basis, a multi-media application using natural images is envisaged, which could readily incorporate images familiar to the individual user, with the possibility of prompting reminiscing.

There is a body of research on aesthetic preferences, including preference for natural landscapes (vs. man-made)[36], together with theory as to why human beings should exhibit such "biophilia"[37], in aesthetics as in other aspects of the human experience. Preference for specific types of landscape most likely to offer food, shelter and security (basic survival needs) may have conferred on evolutionary advantage on individuals who exhibited it. There is also an intriguing theory that the aesthetic (and therapeutic?) value of natural landscapes may lie in their fractal characteristics[38]: patterns occurring in nature, such as leaf mosaics, rock formations, ripples in water, can be described in terms of fractal mathematics, as ever-repeating patterns occurring at different scales. This is referred to as "self-similarity". Preference for natural images and the therapeutic benefits that arise from viewing such scenes both first-hand and second-hand through images may therefore arise for more basic and universal reasons than an evolutionary preference for particular landscapes.

Interpretation of sensoring will actuate the application when certain parameters for measurement of stress are exceeded, supported by machine-learning to facilitate adaptation to an individual. The possibility of over-riding automatic actuation by the user has been considered, and voice- or gesturally-activated interfaces will be included. The data used for actuation is also relevant in terms of monitoring of health status, and may also be relayed to a carer, allowing non-intrusive continuous monitoring. The therapeutic applications might therefore be considered as extensions to existing pervasive healthcare applications. Inputs by carers, for example to activate an application that has previously been identified as being of benefit, may also be facilitated.

Conclusion

The concept of an architectural environment which is responsive to the user has potential beyond the realm of residential healthcare, where it may help improve quality of life, and ameliorate the effects of illness, including dementia. Architects can choose to embrace the possibilities offered by ambient technologies, extending far beyond enabling environmental functionality: the advent of ambient intelligence is as inevitable as the increase in the numbers of the very old.



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