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Optimal spaces for those living with dementia: principles and evidence

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ABSTRACT

This paper presents a synthesis of diverse and disparate evidence in the research literature that provide insights into the impacts of aspects of the built environment on the wellbeing of those living with dementia. The individually focused findings are structured into a set of practical design parameters driven by three overarching needs-driven design principles: manageable cognitive load, clear sequencing and appropriate level of stimulation. These needs are contextualized within a general model that suggests that action in any one area (such as the built environment) also has to take into account other key dimensions, namely any support from the caring/social environment and any pharmacological treatment. Addressing these elements holistically should maximize the opportunity to improve the quality of life of the individual. This paper, however, explicitly focuses on the built environment.

KEYWORDS

built environment; dementia; design principles; ecopsychosocial; evidence-based design; social impacts; treatment

Factors impacting on the living with dementia

Introduction


According to the World Health Organisation (WHO) (2018) dementia is 'one of the major causes of disability and dependency among older people worldwide'. It estimates the scale of the issue is huge and dynamic, with around 50 million people affected presently, projected to rise to 82 million in 2030 and 152 million in 2050. It stresses that there are 'physical, social, and economical impacts, not only on people with dementia, but also on their carers, families and society at large'. On this last aspect, the societal cost of dementia has been estimated at as much as 1.4% of gross domestic product (GDP) in high-income countries. The WHO delivers the bitter fact that 'there is no treatment currently available to cure dementia or to alter its progressive course', but it does stress that there are opportunities to support all involved and improve their quality of life (QoL).


At the centre of efforts to address the personal and societal impacts of dementia is the concept of 'living well with dementia' (Banerjee, 2010; Rahman, 2014). This necessarily implies taking the perspective of the person living with dementia. The proposition presented in this paper is that it is necessary to consider three distinct

dimensions within the person's environment, which together contribute to the person's holistic, lived experience. These environmental dimensions are a logical progression from the person in focus to those around them to the broader material environment, as follows:

- *Pharmacological/medical environment*, i.e. the drugs prescribed and the medical treatments given to ameliorate the symptoms of the patient's condition.
- *Social and care/support environment*: includes all aspects of support from *people* ranging from social activities, relatives, friends, and the full range of informal and formal care at varying depths of involvement.
- *Material environment*: the *things* in the environment delivered in the form of the characteristics of the inhabited internal and urban built spaces and the potential technological support and opportunities which can be accessed.

A large part of recent and past research efforts with respect to dementia have been focused on the first of these dimensions. The latter two dimensions have received less attention, although more recently they have collectively been termed 'ecopsychosocial' factors (Zeisel, Reisberg, Whitehouse, Woods, & Verheul,

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2016). To grasp fully the optimum way forward for a particular individual, the combined holistic impact of *all* these dimensions on that specific person living with dementia in specific environments needs to be made explicit. This is, of course, how people actually experience daily life – not in the discrete elements of what is around them, but through their combined impact.

Proposed holistic research landscape

Figure 1 presents an holistic view of the dementia research landscape taking into account the material, social and pharmacological context. This essential ‘hope’ model intrinsically accepts that a person with dementia can maintain a reasonable level of QoL for a significant part of their journey with the condition. The bottom curve represents the general decline in the individual’s QoL, reflecting observed reality as well as general models of long-term life trends in brain functioning (Organisation for Economic Co-operation and Development (OECD), 2002). The successive curves above this baseline suggest that the individual’s ‘intrinsic’ capacity can be augmented by a combination of the empowerment provided by the physical/technological environment, the support of the caring/social environment plus treatment through pharmacological and medical means, where appropriate. Separately and together they can work to deliver a greatly enhanced ‘effective capacity’ for the person to live well with dementia. In sum, ‘hope’ lies in the reality that interventions in these areas can actually make a difference.

Major research questions implied by this model include:

- How does one typify and measure the experienced intensity of the three contextual dimensions?
- How does one typify and measure the capacity/QoL of those living with dementia?

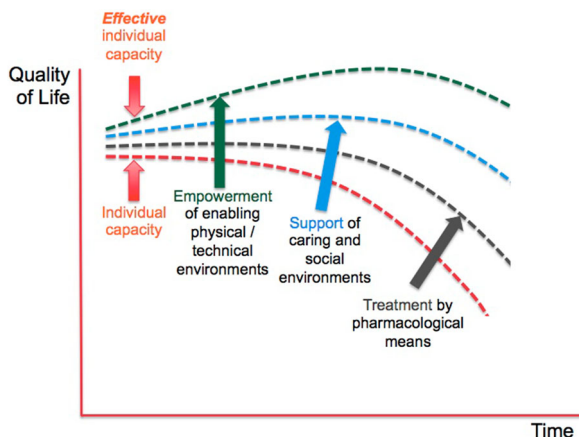


Figure 1. Holistic dementia research landscape.

- How does one identify different broad categories, or ‘living profiles’, of people living with dementia where the factors impact differently, *e.g.* age, gender, stage, culture *etc*?
- How does one understand the interactive/synergistic effects between the three contextual dimensions?
- How does one identify key transition points in care and support needs and the effective responses at these points?

Knowledge gaps identified

The initial consideration of these questions using a combination of individual desk research and workshops with co-researchers has established a rough, initial view of the current baseline of knowledge around metrics for the various dimensions of the research landscape. The findings can be summarized as follows:

- *QoL measures*: the most relevant dependent variable in the present research landscape. ‘There is no consensus in the scientific literature on the core domains of QoL’ (Pietersma, de Vries, & van den Akker-van Marle, 2014, p. 1543). Specifically for dementia, Bowling et al. (2015) have carried out an extensive review. The front-running measure is QOL-AD (QoL in Alzheimer’s disease), but the 15 items used do not have an underpinning logic and Bowling concludes that broader measures created with those living with dementia are needed.
- *Pharmacological environment*: encapsulated in the Cochrane Reviews that have been carried out in the area of dementia. There have been over 100 relevant reviews completed and at a rough assessment¹ about one-quarter show some benefit of a given treatment, one-quarter show no benefit and the remaining half provide inconsistent or insufficient evidence. It has been suggested in a recent US National Academies publication (Committee on Preventing Dementia and Cognitive Impairment, 2017) that the strength of randomised controlled trial studies, favoured in the Cochrane Reviews, is also a weakness in that ‘while they are particularly effective for testing single-intervention solutions, the apparent complexity of the pathophysiology underlying cognitive decline and dementia suggests that a multifaceted approach may be most effective’ (p. 11). This resonates with the high level of ‘inconsistent’ results, which are likely to be a consequence of confounding, non-pharmacological factors.
- *Care/support environment*: only general statements exist regarding the stages at which certain types of care may be needed (WHO & Alzheimer’s Disease International, 2012) and an extensive survey of care

options based on where they are delivered (Hallberg et al., 2013). With the exception of the specific area of psychological therapies (Department of Health, Social Services and Public Safety (DHSSPS), 2010), there is no objective measure of the *intensity* of caring support provided by *people*, either trained or not.

- *Material environment*: comprising the built aspect and technology.
- *Built environment*: a significant amount of isolated evidence exists for the impacts of specific elements (say, light levels) on those living with dementia, but there is only one ‘holistic’ study by Zeisel et al. (2003). This study assessed eight aspects of care facility design and found statistically significant evidence for the impacts of five of them. In addition, there are several general tools for assessing ‘design quality’ and a subset focused on design for dementia. Of these, the King’s Fund approach is probably the best known (Coulter, Roberts, & Dixon, 2003). This tool explicitly mentions the needs of users, but does not accommodate all the evidence and in places goes beyond it. As in the other areas explored above, there is no objective measure of the *intensity* of the support provided by the built or physical environment.
- *Technological environment*: the literature and an active marketplace focuses on devices, each mainly targeted at a specific need. There is an emphasis on safety and especially alerts in the case of falls, together with an array of prompts and reminders. New directions are emerging in the area of sensor technologies and monitoring, at its most extreme in the form of ‘smart homes’ (Bennett, Rokas, & Chen, 2017). The emphasis is on technical feasibility, with some connection to identified needs, but lacking evidence of impacts. Again, there is no objective measure of the *intensity* of the support provided by the technological environment (Parker, Mills, & Abbey, 2008).

It can be seen that, surprisingly, there are large gaps in the available metrics, especially if the intensity of the various types of support is factored in. Filling these gaps is crucial if an holistic approach of the type set out above is to be operationalized.

This is a large task. Therefore, this paper focuses just on the built-environment aspect of the ‘material’ environment. It gathers together the wide-ranging evidence for the impacts of the physical environment on those living with dementia, but crucially it seeks to put this material within as simple a conceptual framework as possible. In doing this, actionable design principles surface, so that practical impacts rooted in the detailed evidence can be stimulated in practice. The scale and urgency of the issues affecting those living

with dementia can be seen to demand this emphasis on links to action.

Methods

The methods adopted are based on secondary sources and driven by the twin features of the current state of knowledge in this area. As set out above, this can be typified, first, as the existence of a lot of isolated pieces of evidence about particular aspects (what Scambler, 2001, has termed ‘demi-regularities’); and, second, a relative gap in relation to the adoption of a person-centric, holistic view. The purpose of this paper is to address this latter gap, whilst building on the evidence that exists.

This led to a two-pronged approach: first, a bottom-up approach based on the literature and, more particularly, studies that provide clear evidence of impacts of the built environment; and second, a top-down approach driven by a strategic consideration of the needs of the person living with dementia. The latter was then used to sharpen the structuring of the emergent issues from the bottom-up effort and to reassess the utility of the conceptual framework being used.

This approach drew on several complementary methodological traditions. In order to collect and synthesize the evidence within the literature in support of gaining a clearer overview, an approach was taken that has features of a grounded theory approach (Glaser & Strauss, 1967; Strauss & Corbin, 1990), especially in its determination to be rooted in reality, as represented by the evidence, and to let categories within the data emerge naturally and iteratively. The progressive articulation of these emergent categories with broad conceptual ideas builds on soft systems’ ideas of cycling between ‘the real world’ and theoretical models (Checkland, 1993). This continues until, in the realist tradition (Sayer, 1992), the coverage and fit between them reinforces the probable ‘practical adequacy’ of the schema developed. This progressive process also reflects more recent grounded theory notions where the approach is not typified as either inductive or deductive, but rather an interactive ‘truth-tracking’ process (Gibson & Hartman, 2014) linking building blocks of theory and practice within broader frameworks of understanding (Barrett & Barrett, 2003).

It is impossible to reflect fully the iterative nature of the process in linear written form, so this paper is written as if the bottom-up literature review were carried out leading to categories of issues that were then drawn into a broader top-down conceptual model. In reality, the process was messier than this and accommodations were made in the various possible classifications until a good level of fit was achieved within a framework that was felt to be

logical and compelling in itself, as well as strongly connected to the available detailed items of evidence.

Within this broad context, some further details of the methodology employed are given in the respective sections below.

Bottom-up synthesis from the literature

General approach

Grant and Booth (2009) assess 14 different approaches to literature reviews and highlight the relative strengths and weaknesses of each. Given the thrust of this study, a ‘critical review’ approach was clearly optimal as it provides the opportunity to ‘take stock [and] provide a launch pad for a new phase’ by drawing material from diverse sources and traditions (p. 93). A consequence of this necessary flexibility is that critical reviews are not as ‘systematic’ as some approaches, as the study designs encountered are varied and so the assessment criteria are necessarily more subjective. That said, in this study many potential sources were driven by rhetoric or aesthetic appeal, but these were sifted out and, as far as possible, only the sources based on sound empirical evidence were included. In this way the approach used displays elements of ‘systematic search and review’ (p. 102). As Hart (1998) points out, ‘All reviews, irrespective of the topic, are written from a particular perspective or standpoint of the reviewer’ (p. 25). However, to make this process of review more robust, a team of two researchers was formed so affording the opportunity for investigator and theoretical triangulation (Denzin, 1970) around the emerging themes.

Initial consideration of scope

The literature was surveyed using search engines that scanned databases of journal papers. The following three types of data search were conducted: database; hand search; and snow ball, *i.e.* looking at the reference list of the most relevant journal papers. The databases included Science Direct, Academic Search Premier, CINAHL, Google Scholar, MEDLINE via EBSCOhost, Web of Science and Ovid Abstracts. Typical keywords used were: (dementia), (built environment), (sensory enhancement and environments), (wellbeing and building environments), (environments for living well with dementia), (Quality of life for people with dementia and built environments). From this initial sift, 185 papers published between 1981 and 2016 were carefully reviewed and then only included if they contained empirically derived evidence of the impact of some aspect of the physical design of the built environment on those living with dementia. Working

from these papers to other related sources added further evidential papers, resulting in a resource of 86 individual papers, each with evidence of one or more impacts (positive or negative) driven by one or more aspects of the built environment.

These sources are listed in the Table A1 in the supplemental data online.² Although it is helpful to collect the published sources of evidence together into one place, the objective was to synthesize this material so that, out of the detail of the studies, major dimensions can be identified. Thus, whilst respecting the granularity of the individual studies, we present here two iterations of condensation leading to a simpler categorization reflecting the broad ambient factors that generally impact those living with dementia.

Given the built environment focus of this analysis, the initial categorization taken was a simple, spatial split, namely: internal spaces, external spaces and the way-finding/circulation spaces between (Table 1).

What emerges strongly from this initial exercise is that there is an entire category of factors concerning ‘sensory enhancement’ that cut across all the physical spaces. Grouped together at the end of Table 1, these factors appear to relate to the issue of providing the appropriate level of stimulation for occupants.

What also becomes apparent is that although there are strong attitudes and opinions, and an intuitive sense as to the importance of external spaces, there is actually very little evidence for the impact of external spaces in the context of dementia (Whear et al., 2014). What studies there are lack meta-analyses and thus the picture remains relatively unclear regarding the actual benefits of designed garden spaces for people with dementia. Further, there is a lack of correlation between incorporated interventions, their evaluation and outcomes. One of the key issues that past studies have identified and that has implications for outcomes is the accessibility of the gardens/external spaces for residents either alone or accompanied. This area requires more research, but for the purposes of this exercise it was excluded from here on, although, as will be seen, some aspects do appear within the categories taken forward. Now a distinction with external spaces is not needed, and reflecting on the issues under ‘internal spaces’ they can be better typified under a heading of ‘scale/familiarity’.

Based on this initial exercise, we focused on the following three categories: scale/familiarity, way finding/circulation spaces and appropriate levels of stimulation. Reviewing the factors in Table 1, a clear spatial distinction emerges between the issues as they operate in personal spaces compared with shared spaces. This is most clearly seen in the area of ‘internal spaces’ where the issue of ‘individual space’ sits alongside issues of ‘social environment’, with questions of ‘privacy and

Table 1. Emergent built environment issues identified from the literature review.

Initial categories	Examples of evidenced issues in the literature (positive and negative)
Internal spaces	Individual space, privacy and opportunity for personalization (<i>i.e.</i> wall decoration, pictures, towels <i>etc.</i>) Environments that respond to users' needs Invasion of privacy and autonomy Individual space, home-like dining atmosphere Non-institutional seating arrangement (<i>i.e.</i> dining area)/home-like dining atmosphere Non-familiar atmosphere. Institutional bathing area Non-recognizable settings/environment Small size environment (5–15 people)/small number of people eating or seated together Homelike/residential characteristics/familiar setting Privacy, person-centred showering Private/double/single room/adequate size/individual rooms Common space/distinctive space Social environment/activity area Spatial proximity of communal spaces Opportunity for ordinary activities Snoezelen room
External spaces	Accessibility to outdoor spaces/external spaces, unlocking door to the common courtyard Outdoor natural environment, well established design theme garden (landscaped garden)
Way-finding/circulation spaces	Exit control/camouflaging techniques (by wall murals <i>etc.</i> , silent electronic door locks) Domestic looking corridor spaces, small number of doors and exit points Environmental information, signs/labels, objects visible, distracting items removed, verbal clues, toilets spatially located in high visual-access area, clock in dining area, signs/landmarks Personal cues, labelled drawers and closet doors/closet modification, objects visible, less clutter, written names, photographs as young adults Direct visual access between spaces, reference points, sightlines between spaces Unique character, central location of nursing station
Sensory enhancement*	Lighting: Increased overall lighting level at the dining table plus enhancing the visual contrast of table ware Exposure to bright light Light therapy Exposure to indirect bright light Low lighting condition Noise: Moderate level of sound Auditory stimuli; home and nature environment High level of noise Colour, contrast and patterns: High-contrast table cloth, placemats, dishes and so forth for dining Lower colour contrast Floor patterns with dark lines Sensory comprehension/conception: Visual, auditory, tactile, smell <i>etc.</i> Auditory stimulation Music and use of pictures Any visual, auditory, tactile and olfactory stimulation/enhancement

*Note: Degree and type of stimulation provided is important.

autonomy' at the intersection. It was therefore decided to treat the personal–shared space dichotomy as an overlay to the three categories identified above.

Thus, the analytical framework employed to organize the findings of the 86 individual studies further is as shown in [Table 2](#).

Table 2. Analytical framework to structure issues from the literature in Appendix A in the supplemental data online.

	Scale/ familiarity	Way-finding/ circulation	Appropriate level of stimulation
Personal spaces			
Shared spaces			

Detailed examination of the evidence base of impactful studies

Table A1 in the supplemental data online employs this framework to structure the referenced studies. The first two columns distinguish the three categories within the broad classification of personal/internal spaces, followed by a synthesis across the studies of 56 identified *factors*. Their evidenced impacts are provided in the fourth and fifth columns. These factors are numbered in the third column and the sources in the literature evidencing the impacts are provided in the sixth column.

Table A1 indicates that there is a reasonable volume of evidence-based studies in each of the cells of the analytical framework given in [Table 2](#). Further, the

Table 3. Summary table drawing from Zeisel (2009) of physical damage, the impacts on cognition and possible enabling responses in the design of the environment.

Aspect	Early	Middle	Later
Physical	Hippocampus damaged		
Cognitive	Problems <i>indexing and retrieving</i> memories (but memories there)		
Enabling response	Need trigger prompts		
Physical	Executive function area in frontal lobe reduced		
Cognitive	Hard-to-organize events into sequences		
Enabling response	Need sequence cues and prompts		
Physical	Orbital frontal cortex, thalamus and hippocampus damaged		
Cognitive	Loss of control over feelings/social impulse control		
Enabling response	Behavioural cues in environment		
Physical	'Comparer' in the A-10 nucleus of the frontal lobe damaged		
Cognitive	Weakened response to unexpected outcomes		
Enabling response	Avoid situations, e.g. camouflage locked doors		
Physical		Wernicke's and Broca's areas	
Cognitive		Language understanding and word selection respectively impaired	
Enabling response		Provide intuitive design	
Physical		Chiasmatic nucleus damaged	
Cognitive		Internal time clock impaired	
Enabling response		Daylighting and safe access to the outdoors	
Physical			Amygdala <i>healthy</i> in late stages
Cognitive			Emotional responses and sensitivity good
Enabling response			Build on emotional responses – art, drama, creativity

categories comprehensively capture and structure to some degree the factors at play. However, because the factors draw from a bottom-up consideration of a wide range of studies, the logic of how the factors relate to each other within a given area is less clear. In addition 56 factors is still too detailed a level of resolution to see clearly the main mechanism at work. To address these issues, the next section turns to top-down consideration of the driving logic behind why these sorts of factors could have impacts on those living with dementia.

Top-down driving forces for impacts of built environment

Rationale for design principles

The aim in this element of the study is to identify a strong person-centric view of the physical environment, given that at that level of analysis it can be anticipated that clearer 'emergent properties' (Checkland, 1993) will crystallize, which are practically relevant to those living with dementia. Given that dementia is fundamentally

driven by deterioration in the functionality of the brain, it is logical to look to these changes for clues as to the major dimensions and underlying regularities of the issue (Sayer, 1992). These changes can be seen as 'generative mechanisms' for the challenges confronted by those living with dementia and through a creative process of 'retroduction' the goal is to suggest a relatively few design principles that respond to these needs (Sayer, 1992).

Zeisel's (2009) *I'm Still Here* is taken as the source material for the above exercise. It is based on his earlier empirical work, but also a sustained effort to link the impacts observed to the specifics of the cognitive impairment of those living with dementia. Table 3 draws from this text (pp. 63–80) and summarizes the nature of each aspect of the physical changes in the brain, its cognitive implications and possibly enabling responses in the built environment that can ameliorate the impact. It also sets out whether these effects arise in early, middle or late stages. It has to be said that they act cumulatively.

The variety and specificity of the physical features is a reminder that particular issues may be in focus at any

one time for each person. However, focusing on the cognitive impacts at a general level it is suggested that the underlying issues are driven by a reduced capacity to retrieve and process information, and in particular to sequence information, together with reduced behavioural self-control.

Potential enabling responses can be grouped into the following three ‘needs’, which in turn are proposed as design principles to be aimed at in order to provide supportive physical environments for those living with dementia:

- manageable cognitive load
- clear sequencing
- appropriate level of stimulation

Just as the individual factors appeared too detailed, the three needs are lacking in practical elaboration. The following discussion synergistically links the two: merging the bottom-up evidence of impacts from the literature with the broad logic provided by the needs of those living with dementia.

Structuring the evidenced factors within the design principles

The factors given in Table A1 in the supplemental data online were grouped in terms of each of the three top-down design principles in both personal spaces and shared spaces, with the aim of simplifying the built-environment factors into a core set of actionable design parameters.

Manageable cognitive load

This principle gives life to a consideration of the scale and familiarity of the spaces provided. These should as far as possible ‘read’ clearly and be supportive. For personal spaces this draws on factors 1–11 and calls for private, adaptable spaces with familiar, personal contents. In shared spaces factors 25–33 are relevant and stress the importance of a bounded, non-institutional scale to the whole facility and, within that area, legibility with distinctive zones.

Clear sequencing

The principle of clear sequencing links to way-finding, yet works differently in personal space (factors 12–18) as compared with the way it works in shared spaces (factors 34–43). In personal spaces, the emphasis is on prompts to support particular activities. In shared spaces, clear sequencing is more closely linked to making way-finding intuitive through clear spatial connections, destinations and spatial signs/cues. This is what Norman (1990) terms ‘naturally mapped’ environments.

Appropriate level of stimulation

The principle of an appropriate level of stimulation applies across the board. For personal spaces it links to factors 19–24, stressing the benefits of a comfortable and moderately stimulating sensory environment. This applies to shared spaces as well, but examining factors 44–56 makes clear that the principle also extends to providing opportunities for the stimulation of social interaction.

Pulling this together into diagrammatic form, [Figure 2](#) summarizes the three design principles driving 10, condensed, design parameters. These simplified parameters are explicitly rooted in the 56 evidenced factors revealed in the literature.

This model presents a robust framework of design principles linked to the needs of those living with dementia, as well as to more detailed design parameters explicitly rooted in the evidence of impacts from the literature. The dementia holistic evidence and design (HEAD) framework shows three ‘drivers’, *i.e.* manageable cognitive load, clear sequencing and an appropriate level of stimulation for people living with dementia in two types of spaces, namely personal and shared. The articulation in the diagram of the design principles with the parameters emerging from the detailed literature-based evidence represents the result of the truth-tracking process described in the methods section. It highlights that:

- To manage cognitive load, personal spaces must provide the opportunity for privacy/personalization and be user adaptable. Personal spaces must be familiar in nature. Shared spaces, to manage cognitive load, need to be bounded and non-institutional in scale. All spaces must be designed to be legible with any zones created having distinctive qualities.
- To provide clear sequencing in personal spaces the environment must provide prompts that support particular activities. Whereas in shared spaces way-finding needs to be intuitive with a clear sequence of spaces, evident destinations, all supported by spatial signs and cues.
- To create the appropriate level of stimulation, both personal and shared spaces must provide a comfortable and moderately stimulating sensory environment. Shared spaces need to offer opportunities for social interaction.

The broad design parameters provided here are actionable in practice. They can be actioned in a comprehensive, flexible way, all being strongly substantiated by the more detailed evidence.

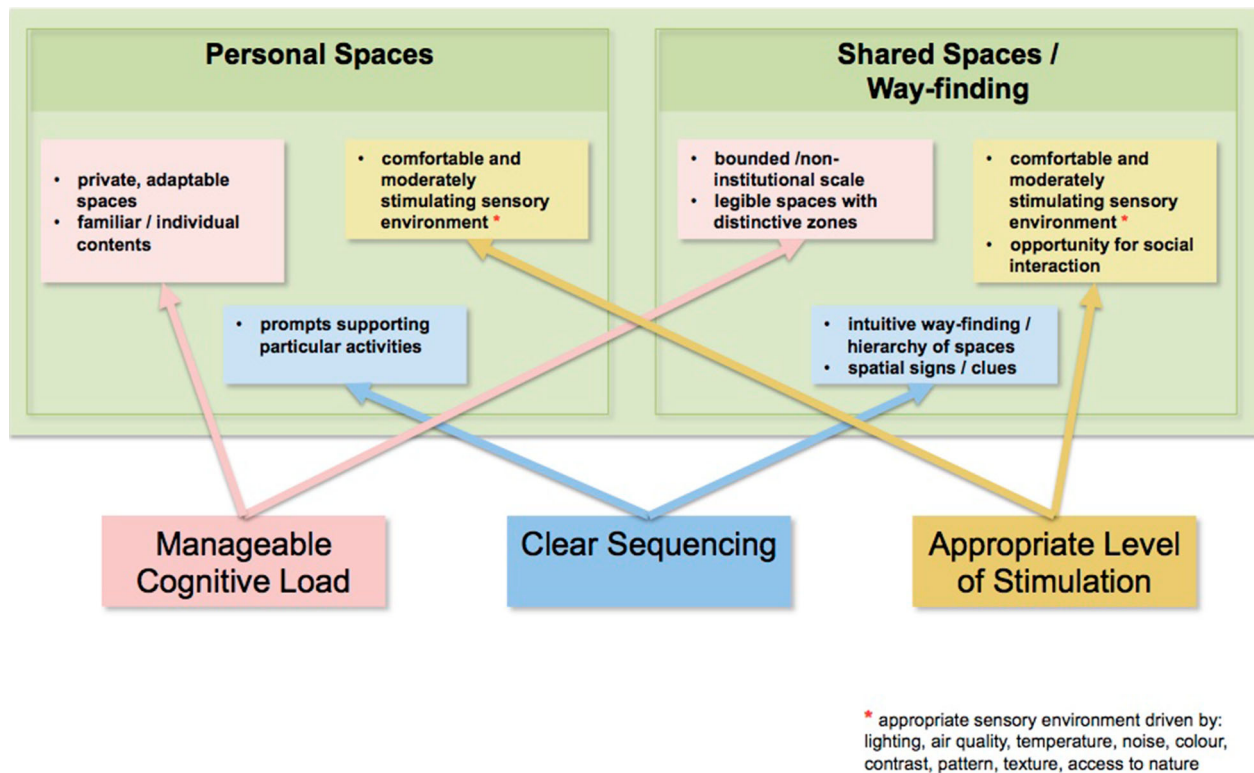


Figure 2. Dementia holistic evidence and design (HEAD) model linking top-down built environment dementia design principles with practical design parameters rooted in the literature.

Conclusions

This paper proposes a broad research landscape to be addressed if a holistic person-centred perspective is to be taken of dementia treatment. We suggest that some combination of support through the material environments, the social environment and pharmacological means must be considered. It is posited that the evidential base is limited in most of these areas regarding the impacts on the QoL of those living with dementia and that the very notion of QoL in this context is hard both to conceive of and to measure. This last point resonates with the findings of recent work in this area, such as Fleming, Goodenough, Low, Chenoweth, and Brodaty (2016).

Against this challenging agenda, this paper focuses on the impacts of the built environment. Here there is much evidence to be found about the impacts of the built environment on those living with dementia. Yet each piece of evidence tends to focus on one or another particular issue, with little evidence concerning holistic impacts in physical settings as experienced in normal life.

The main focus of this paper is therefore a synthesis of the evidence about the built environment to create a small actionable set of design principles, supported by more detailed, strongly evidenced, design parameters.

This is summarized as the dementia HEAD model in Figure 2, offered as a basis for further study and intervention by those supporting those living with dementia.

The authors' driver for the organization of the design principles is akin to Marshall's (1998) 'compensate for disability' in its focus on the changes in the brain of the person living with dementia. This then leads to many of Marshall's other design considerations, such as allowing for the control of stimuli, but it does not extend as broadly to things such as demonstrating care for staff. The focus here has been limited only to the built environment needs of the person with dementia, although the broader model given in Figure 1 does clearly identify the social dimension as an related area for study. Fleming and Purandare's (2010) extensive review of the evidence in the literature using Marshall's list of 11 desirable design features for residential facilities for people with dementia provides an interesting benchmark for the review provided in the present paper. Unsurprisingly, many of the factors in the list are similar to those considered in this paper. Typically, they are at the level of 'design parameters' in our terminology. The evidence is found to vary in strength, for instance, with less agreement around the value of the provision of outside space. The evidence base continues to build slowly and this paper is part of capturing that progress.

What we have added is a reasoned proposition for an additional level of three understandable, actionable design principles.

These principles provide a broad view of the ambient physical design factors that should be conducive to 'living well with dementia' (Banerjee, 2010; Rahman, 2014). Zeisel (2009) lists, among what are generally considered negative symptoms of dementia, the four A's: apathy, anxiety, agitation and aggression. Figure 3 suggests how the design principles described above may be related to, or be effected by, the physical context. Grouping 'clear sequencing' and 'cognitive load' along the *x*-axis as cognitive demand, with 'level of stimulation' along the *y*-axis, it can be seen that the four A's are likely outcomes of the extremes of the four broad combinations provided in the diagram.

If 'living well with dementia' relies at least partially on the absence or minimization of the four A's, this view reinforces the evidence that using the design principles elaborated in this paper can help identify ways to impact positively the QoL of those living with dementia.

It follows that moderate levels of stimulation would contribute to reduced apathy and agitation, whilst a moderate level of cognitive demand should help reduce apathy and anxiety. This latter area deserves further research including the question of the beneficial effects of 'environmental press' (Lawton, 1982). Some challenge, as the environmental press model points out, can be beneficial and this reflects the 'use it or lose it' mantra that is sometimes heard (*e.g.* Zeisel, 2009). To complete the picture, too much on both axes is likely to lead to aggression. The key proposal implicit in this paper is that, judged by the capacities of the individual, the aim of environmental design must be to identify a mid-point where the individual has interest, but is not over-stretched; is stimulated, but not disturbed. Design

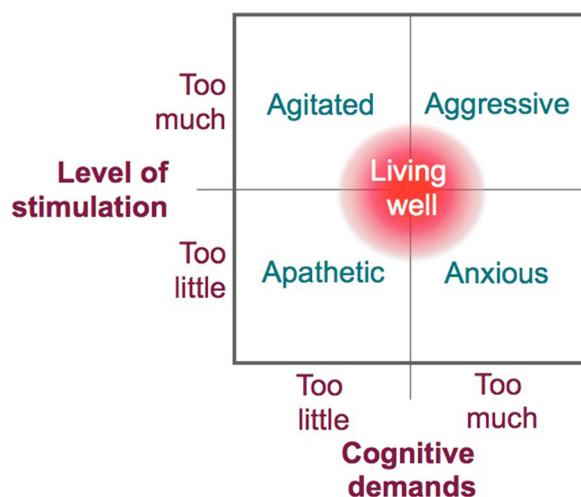


Figure 3. Link between the four A's and the design principles.

parameters available to achieve this subtle balance are set out in Figure 2: the dementia HEAD model.

The authors hope that the general models proposed in this paper lead to further research and design elaborating the models and specifying the needs and design goals of environments that support the QoL of those living with dementia.

Notes

1. Provided in an October 2014 presentation by Sally Spencer, then of Lancaster University, UK, and Editor of the *Cochrane Dementia & Cognitive Improvement Group*. Professor Spencer is now Director of Clinical Research at Edge Hill University, Ormskirk, UK.
2. The following works are mentioned in Table A1 located in the supplementary online data as sources in the literature of built environment factors with evidenced impacts:

Abrahamson, Clark, Perkins, and Arling, 2012; Annerstedt 1993; Annerstedt, 1997; Bellelli et al., 1998; Bianchetti, Benvenuti, Ghisla, Frisoni, and Trabucchi, 1997; Brush, Meehan, and Calkins, 2002; Campo and Chaudhury, 2012; Caspi, 2014; Chard, Liu, and Mulholland, 2009; Charras et al., 2010; Cohen-Mansfield and Parapura-Gill, 2007; Cohen-Mansfield, Thein, Dakheel-Ali, and Marx, 2010; Cohen-Mansfield and Werner, 1995; Cohen-Mansfield and Werner, 1998; Connell, McConnell, and Francis, 2002; Cox, Burns, and Savage, 2004; Cutler and Kane, 2002; Cutler and Kane, 2009; De Rooij et al., 2012; Dean, Briggs, and Lindesay, 1993; Dettbarn-Reggentin, 2005; Dickinson, McLain-Kark, and Marshall-Baker, 1995; Dowling, Graf, Hubbard, and Luxenberg, 2007; Dunn and Riley-Doucet, 2013; Elmstahl, Annerstedt, and Ahlund, 1997; Feliciano, Vore, eBlanc, and Baker, 2004; Funaki, Kaneko, and Okamura, 2005; Garcia et al., 2012; Garre-Olmo et al., 2012; Götestam and Melin, 1987; Graneheim, Norberg, and Jansson, 2001; Gross et al., 2004; Hanley, 1981; Hsieh, 2010; Isaksson, Åström, Sandman, and Karlsson, 2009; Joosse, 2009; Kihlgren et al., 1992; Koss and Gilmore, 1998; Kovach, Weisman, Chaudhury, and Calkins, 1997; Kovach and Stearns, 1994; Lovell, Ancoli-Israel, and Gevirtz, 1995; Malmberg and Zarit, 1993; Marquardt, Bueter, and Motzek, 2014; Marquardt and Schmieg, 2009; Melin and Gotestam, 1981; Milke, Beck, Danes, and Leask, 2009; Mooney and Nicell, 1992; Morgan and Stewart, 1999; Morgan-Brown, Newton, and Ormerod, 2013; Nakanishi, Nakashima, and Sawamura, 2012; Namazi and Johnson, 1996; Namazi and Johnson, 1991; Namazi, Rosner, and Rechlin, 1991; Negley and Manley, 1990; Nelson, 1995; Netten, 1993; Nobili et al., 2008; Nolan, Mathews, and Harrison, 2001; Nolan, Mathews, Truesdell-Todd, and VanDorp, 2002; Nowak

and Davis, 2011; Passini, Pigot, Rainville, and Tétreault, 1998; Reimer, Slaughter, Donaldson, Currie, and Eliasziw, 2004; Riemersma-van der Lek et al., 2008; Roberts, 2011; Rovner, Lucas-Blaustein, Folstein, and Smith, 1990; Sheehan, Burton, and Mitchell, 2006; Sloane et al., 1998; Sloane et al., 2007; Suzuki, Kanamori, Yasuda, and Oshiro, 2008; Swanson, Maas, and Buckwalter, 1993; Thistleton, Warmuth, and Joseph, 2012; Thorpe, Middleton, Russell, and Stewart, 2000; van Hoof, Schoutens, and Aarts, 2009; van Mierlo, Van der Roest, Meiland, and Dröes, 2010; van Someren, Kessler, Mirmiran, and Swaab, 1997; Verbeek et al., 2010, Waller and Masterson, 2015; Webber, Breuer, and Lindeman, 1995; Weyer, Schaeufele, and Hendlmeier, 2010; Whall et al., 1997; Wilkes et al., 2005; WHO, 2012; Yao and Algase, 2006; Zimmerman et al., 2017.

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