Literature Review

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Built Environment Design Interventions at the Exits of Secured Dementia Care Units: A Review of the Empirical Literature

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Abstract

Purpose: To review evidence around design interventions that influence exiting attempts in dementia care units, informing architectural and clinical practice. **Background:** Built environment design is recognized as important in the care and management of responsive behaviors for those living with Alzheimer's disease and other dementias in secured dementia care units (e.g., exiting attempts, agitation). The repetitious behavior of "walking with purpose" (previously termed wandering) in those with dementia has influenced safety-related architectural design components of dementia care units that decrease exiting attempts. Empirical literature addressing design interventions to prevent exiting for those with dementia is lacking and outdated. **Methods:** We sought to describe known design techniques through a topical analysis of experimental studies. A thorough search for empirical studies that assessed interior design interventions at exit doors within dementia care units was undertaken. The review included an extensive search for existing literature and a screening of each study identified for its relevance, quality, and applicability. **Results:** The experimental studies included in the review collectively assessed five interior design interventions at egress doorways: implementing horizontal and vertical floor grid patterns, mirrors, murals, conditioning responses to color cues, and camouflaging door hardware or vision panels. Why empirical studies have not continued more recently as built environment trends have shifted toward promoting meaningful and purposeful movement through design are considered. Advances in our understanding around the pathophysiology of dementia which might affect future design interventions related to egress are also identified. **Conclusion:** The built environment is an important part of dementia care, and further prospective research is needed on the role of design interventions in the context of exiting attempts within secured units and subsequent behavior outcomes.

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The design of the physical environment is increasingly recognized as important in the care and management of behaviors for persons with dementia (PWD), including Alzheimer's disease (AD) and other dementias (Chaudhury et al., 2018; Day et al., 2000; Marquardt et al., 2014; Parke et al., 2017; Parke & Friesen, 2015). "Walking with purpose," formerly termed "wandering," (Fallon et al., 2020) is a common behavioral symptom of dementia. This newer terminology might best apply to people exhibiting the ability to consciously identify the "purpose" of their walking, which those in later stages of dementia are often unable to do and may more accurately be described as walking to unclear destinations. For the purposes of this review, we will utilize the newer and known terminology in the literature. Walking with purpose may be a behavioral response to one's environment such as stress in the case of over/under stimuli or lack of choice and control (Desai & Grossberg, 2001). It can include aimless and/or goal-directed activity and manifest as frequent walking and attempts to exit a space (Budson & Kowall, 2011; Dickinson & McLain-Kark, 1998; Gu, 2015). While this responsive behavior may not inherently be a problem for the person doing the activity, it can be challenging to manage for caregivers and presents a safety concern when it includes attempts to leave facilities or homes (Lai & Arthur, 2003), which can lead to elopement, getting lost, injury, and possibly death (Algase et al., 2010).

Dementia care units are typically for those with various types of dementia and are generally secure to prevent elopement—they can be standalone facilities or designated areas within institutional long-term care settings. While these are also often known as memory care units in the literature, we have chosen to refer to them as "dementia care units" for the purposes of this review—while memory is frequently the predominant cognitive domain affected by this type of disease process, other domains may be affected as well (e.g., language, attention, executive function). Also for the purposes of this review, exit doors within the institutional setting are considered part of a means of egress, usually leading from the floor area they serve to a separate building, an open public thoroughfare, or an exterior open space. Methods of preventing or limiting PWD from walking with purpose in healthcare and institutional settings have included alarms, locking external doors, physical restraint, or chemical restraint with the use of sedating medications (Dickinson et al., 1995; Namazi et al., 1989). Dickinson and McLain-Kark (1998) note that chemical restraint to prevent exiting behaviors "is only a temporary solution if the exiting is associated with the design of the facility" (p. 24).

The way the built environment is designed is thought to impact behavior for PWD, and previous studies have looked at environmental factors that may impact walking with purpose. For example, overall unit configuration plays a key role in the ability for PWD to navigate their environment independently, with certain layouts lessening spatial disorientation when social spaces such as dining and activity zones are located in close proximity to one another (Chaudhury et al., 2018). It has been hypothesized that environments with limited stimulation can induce stress or boredom and further exacerbate the need to walk with purpose (Kolanowski et al., 2002; Rader et al., 1985). In contrast, overstimulation in the form of acoustics can also be problematic—too much noise in the environment can cause residents in institutional settings to react and become agitated (Cohen-Mansfield, 2001). Evidence exists to support noise reduction in institutional settings to decrease undesired behaviors (Jensen & Padilla, 2017).

Specific physical environment interventions also aim to support the behavior of walking with purpose and have shown promise, including

designated "wandering areas" (McMinn & Hinton, 2000), incorporation of "wandering paths" (Dickinson et al., 1995; Webber et al., 1995), and leaving exits doors unlocked to allow access to secured outdoor spaces (Namazi & Johnson, 1992). Detweiler et al. (2008) found that the provision of a "wander garden" influenced the behavior in a sample of 12 male veterans; within a year of the garden opening, all participants demonstrated a reduced need for psychotropic medications and reduced agitation levels (Detweiler et al., 2008, p. 32). Algase et al. (2010) evaluated associations between environmental variables and walking with purpose and found a higher likelihood of this responsive behavior in hallways, suggesting the need to limit or minimize these spaces. The authors also note walking with purpose to be less frequent in spaces with more social interaction, when surroundings had a soothing quality, or where rooms had a designated purpose (e.g., an activity room). PWD were more likely to walk with purpose in brightly lit locations, where there was a greater variation in sound levels, and where surroundings were more engaging with materials or activities (Algase et al., 2010). Of note, walking in some areas over others might suggest that residents are trying to get away from other spaces such as in the case of overstimulus from noise.

While recent design trends in dementia care units have included a shift toward more homelike, domestic scale units to support autonomy and individualized care, including the design of easily navigable spaces to reduce walking with purpose (Algase et al., 2010), there is an overall paucity of intervention studies. Of note, walking itself should not necessarily be considered a problematic behavior, and it may be a way of reducing boredom or as a deliberate means of getting exercise within the institutional setting. One study found that implementing a walking exercise program could make a substantial contribution to the physical mobility, function, and quality of life of nursing home residents with AD (Tappen & Kronk, 2001).

The repetitious behavior of walking with purpose has influenced architectural design components within specialty dementia care units (Kincaid & Peacock, 2003) with the implementation of low-cost and minimally restrictive environmental manipulations aimed at specifically decreasing exiting attempts that often accompany this responsive behavior (Feliciano et al., 2004). Although design guidelines offer hypotheses for how the built space may promote well-being and safety for those with cognitive impairment, not all guidance refers to empirical research to justify recommendations. Day et al. (2000, p. 398) note wisely that "empirical research is needed to resolve situations in which conflicting design recommendations are offered."

To the best of our knowledge, published research on design and dementia began around the 1980s (Calkins, 1988; Fleming & Bowless, 1987). Since then, several papers provide reviews on the empirical research related to facility planning, environmental attributes, overall building organization, and specific rooms (Chaudhury et al., 2018; Day et al., 2000; Marquardt et al., 2014; Parke et al., 2017; Parke & Friesen, 2015). While there are a number of empirical studies addressing design interventions to prevent exiting in the institutional built environment for PWD, they are outdated. To our knowledge, there has not been a comprehensive review of empirically tested built environment design interventions intended to prevent unsafe exiting attempts in the setting of secured dementia care units or an analysis of why certain interventions work over others based on known neuropathological processes in AD and other dementias.

Search Methods

A systematic literature search was used to identify potential studies for review. The initial method involved a keyword search of several databases: MEDLINE, Google Scholar, web of science, AgeLine, CINAHL, PsycINFO, and academic search. The search was carried out using the following keyword groupings to designate type of unit and design intervention: *wandering or dementia or memory care unit, and built environment or physical environment or facility design or interior design or architecture or design intervention, and floor pattern or visual barrier*. Of note, "floor pattern" was chosen based on the research team's knowledge of this technique and "visual barrier" was included

alongside in order ensure inclusion of other potential interior design interventions. Potential studies were also identified by reviewing all issues (from the initial year of publication 2007 onward) of the *Health Environments Research and Design (HERD) Journal*, the lead peer-reviewed source on evidence-based design resource. In addition to interventional studies, the literature search identified systematic reviews focused specifically on therapeutic design and dementia (Chaudhury et al., 2018; Day et al., 2000; Marquardt et al., 2014; Parke et al., 2017; Parke & Friesen, 2015), as well as physical design standards for healthcare settings geared toward PWD (Parke & Friesen, 2015). Finally, reference lists were inspected of all studies included in this review for further empirical literature.

A thematic approach was used in this review of the literature. We felt an initial conceptualization of design interventions in the context of exiting in dementia care units was lacking in the literature. Further, we believed the knowledge from a synthesis and critical analysis of the empirical literature alongside current neurological mechanisms could offer new perspectives and knowledge on the topic.

Thirteen appropriate interventional studies were identified based on criteria that the studies incorporated design elements in the built environment to investigate their effect on exiting behaviors for PWD in dementia care units. In each case, articles which were identified as potentially relevant (by title and abstract, if possible) were collected and assessed for appropriateness/relevance. One study retrieved was excluded as it assessed physical environment cues aimed at reducing problems with wandering related to incontinence and not egress (Namazi & Johnson, 1991).

Eleven empirical studies published from 1982 to 2004 were included in this review. In addition, an unpublished master's thesis was retrieved and included (Hamilton, 1993). The 12 studies included in this review met the following criteria: a report of empirical research, written in English, not limited by year of publication, an emphasis on any type of dementia within any setting (not limited to specialty dementia care units, although all studies found were within institutional settings) and a substantial emphasis on design intervention used in the context of exiting behaviors. One of the studies retrieved was included given the relevance of the interventions and citation by other papers, although there was lack of information around study design and methodology used (Roberts, 1999). Another paper included in our review consisted of three studies, but only one was included as it assessed color cues and exiting attempts; the other two interventions were excluded as they assessed behavioral symptoms unrelated to walking with purpose and exiting behaviors (Hussian, 1982).

Results

The 12 empirical studies retrieved collectively assessed five design interventions in dementia care to limit exiting behaviors, all located at egress doorways. These included the application of horizontal and vertical floor grid patterns, mirror placement, painting murals, conditioning responses to color cues, and disguising door hardware or door windows through camouflage techniques. Of note, in several of studies reviewed, it was not always clear where the exit door(s) under investigation led, whether to adjacent indoor spaces or outdoor areas. See Table 1 for a summary of key information from the studies retrieved and included in this review.

Floor Patterns

It has been observed that those with AD and related dementias appear to be affected by certain visual stimuli that do not affect the walking behavior of people without dementia or staff members, such as a grid pattern. PWD have been observed deliberately stepping over the point where floor tiles change color (Hewawasam, 1996). They have also been observed to avoid areas of extreme glare or shiny floors (Hewawasam, 1996; Hussian & Brown, 1987). Onlookers have noted that some who avoid these areas do so while commenting about "spilled water" (Hussian & Brown, 1987). Studies have found that a basic horizontal grid pattern in front of egress doorways can reduce exit attempts (Hewawasam, 1996; Hussian & Brown, 1987; Roberts, 1999),

Table 1. Summary of Key Information on the Studies Reviewed on Design Interventions at the Exits of Secured Dementia Care Units (Ordered According to Publication Year).

No.	Investigational Study	Research Design; Discipline	n (Male: Female)	Facility Type	Mean Length of Stay (months)	Mean Age (Years)	Dementia Type (n)	Baseline Testing Mean Score (Range)	Intervention to Physical Environment Design	Outcome Measures	Key Findings of Environmental Design Interventions
1	Hussian (1982) *Study 1	Observational; Gerontology	3	Long term care	13	73.4	**AD (3)** No data (3)	No data	Color cues: two sets of stimuli with conditioning using large colored cardboard geometric shapes placed near exits: • orange rectangles for positive associations • blue circles for negative associations	Number of entries into potentially hazardous areas (defined as elevators, kitchens, stairwells and exterior exits)	A reduction of inappropriate entries noted in all 3 participants; • the reduction continued after intervention during a series of fading steps where cardboard cues were reduced in size until eventually no artificial stimuli was used
2	Hussian and Brown (1987)	Observational; Gerontology	8 (8:0)	Psychiatric hospital	7.9	78.5	Primary degenerative dementia, senile onset (8) • 7 severe dementia • 1 moderate dementia	11-point mental status examination 2.5 (0-6)	Beige masking tape floor grid configurations in front of exit door: • 3, 4, 6, 8 and 10-strip horizontal grid configurations ending 0.91 m from end of hall • 8-strip horizontal grid flush with end of hall • ten-strip horizontal grid • vertical grid configuration	Whether grid pattern was crossed or not during free ambulation to make exit door contact (crossing considered if subject stepped beyond or reached across final tape)	The 8-strip horizontal grid pattern ending 57.2 cm from door was most effective at preventing exits: • 98% exit-door contact without any grid; • reduced to 45% with three, four, and six tape strip configurations; • vertical striping was less effective at terminating ambulation vs horizontal
3	Namazi, Rosner and Calkins (1989)	Observational: Geriatrics/ Psychiatry	9 (4:5)	Dementia unit of multilevel nursing care facility	24	76	**Senile AD (9)** • All with visual agnosia on exam	MMSE 0 PMSQ 0 (one subject scored 1 on PMSQ)	7 types of exit door visual barriers: • brown vs beige horizontal floor tape strips • black tape at 45-degree angle on floor and partway up door • beige vs green patterned cloth panels to match door color covering door knob • painted doorknob beige to match door • hard doorknob cover (knob turns with applied pressure)	Number of exiting attempts based on number of times door alarm sounded	• Floor tape patterns increased total and average number of exits from baseline; • Conditions targeting visual agnosia (cloth panels, doorknob covers) deterred residents from exiting more than tape patterns; • Cloth panels were more effective than doorknob covers with 0 exits, and both resulted in fewer exits than the floor patterns

(continued)

Table 1. (continued)

No.	Investigational Study	Research Design; Discipline	n (Male: Female)	Facility Type	Mean Length of Stay (months)	Mean Age (Years)	Dementia Type (n)	Baseline Testing Mean Score (Range)	Intervention to Physical Environment Design	Outcome Measures	Key Findings of Environmental Design Interventions
4	Chafetz (1990)	Observational; Gerontology	30 (2:28)	Specialized care unit (SCU) for dementia	No data	81.1	23 tested: **SDAT (15)** MID (3) Mixed/ other (5)	MMSE 9 (0-17) GDS 5.9 (5-7)	8 horizontal floor strips of black tape placed in front of exit door (SCU on ground floor, each exit consisted of glass double doors)	• Buzz data: frequency of door openings (indicated by the sounding of the buzzer when exit door was opened • Stop data: frequency of distractions by staff for residents who appeared to be about to open an exit door	Grid installation corresponded with a nonsignificant increase in exiting for both the buzz and stop data; • observation of lowered frequency of exiting attempts post-intervention; • vision panels with outdoor views in doors thought to distract attention from grid
5	Mayer and Darby (1991)	Observational; Geriatrics/ Psychiatry	9 (1:8)	Psychogeriatric ward	13.3	77.8	**AD (6)** MID (3)	MMSE $\leq$ 12 CAPE: mean dependency of E (severe cognitive impairment)	2 test conditions: • Full-length mirror placed 30 cm in front of main exit door (reflective) • Reversed mirror placed 30 cm in front of main exit door (not reflective)	• All approaches to exit door past prearranged point (imaginary line $\sim$2 m from door) • Outcome of approach (staring, touch mirror, move mirror) • Any door contact (touch, open, exit)	• Mirror use significantly reduced door exiting overall (from 76.2% to 35.7%, $p < .02$); some patients had increased approach frequency, others reduced all door contact; • Door contact rate fell when reverse mirror used compared to no mirror (not significant, $p = .062$)
6	Hamilton (1993) *unpublished master's thesis	Observational; Housing/ Interior Design	11 (5:6)	Dementia care unit	7.5	80.7	**AD (4)** **Senile AD (1)** SD (2) MID (1) "Dementia" (1) OBS (1) PD (1)	No data	2 test conditions: • horizontal strips of black tape applied to floor in front of exit door (black selected to create visual contrast with beige floor); • horizontal strips of red tape applied to floor in from of exit door	Number of times alarm sounded at the fire exit door	Reduced exiting attempts were not statistically significant; • black tape pattern: largest decrease from baseline reducing exiting attempts by 19.05%; • red tape pattern: reduced exiting attempts by 11.12% from baseline

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Table 1. (continued)

No.	Investigational Study	Research Design; Discipline	n (Male: Female)	Facility Type	Mean Length of Stay (months)	Mean Age (Years)	Dementia Type (n)	Baseline Testing Mean Score (Range)	Intervention to Physical Environment Design	Outcome Measures	Key Findings of Environmental Design Interventions
7	Dickinson et al. (1995)	Observational; Gerontology	7 (5:2)	Dementia care unit	Range 3–53	Range 70–87	**AD** or other	No data	Three interventions: • mini-blind covering door vision panel • cloth panel over the door handle bar • combination of both mini-blind and cloth panel (both blue to match door color)	Frequency of exiting attempts (coming into contact with the exit bar on the door)	Cloth panel most successful intervention: • mini-blind marginally significant with a exiting attempt reduction of 44% • using both interventions statistically significant with a reduction of 88% • cloth barrier over the door handle statistically significant with exiting attempt reduction of 96% (most effective intervention)
8	Hewawasam (1996)	Observational; Gerontology/ Nursing	10 (3:7)	Hospital for "elderly mentally infirm" (EMI)	9	76	"Severe dementia" (6) "Moderate dementia" (4)	5-pt MMSE 8 (0-30)	Horizontal and vertical configurations of eight strips of black tape placed on the floor in front of the exit door	Number of times each patient made contact with the main door	• Horizontal grid was found to limit hazardous "wandering," half the patients showed a statistically significant reduction in the number of door contacts (4/5 of these had a previous diagnosis of Alzheimer's disease) • Vertical grid configuration was less effective
9	Dickinson and McLain-Kark (1998)	Observational; Gerontology	8 (5:3)	Dementia care unit	24	No data	**AD (4)** PD (1) MID (1) SD (1) No diagnosis (1)	No data	Three intervention conditions: • mini-blind that covering the window of the exit door • cloth panel covering the panic bar of the door • combination of both	The number of exiting attempts (defined as pushing on the door handle)	• The cloth covering for the door handle was the most effective intervention • The mini-blind did not seem to prevent patients from attempting to examine or interact with the bar, which led to some door openings

(continued)

Table 1. (continued)

No.	Investigational Study	Research Design; Discipline	n (Male: Female)	Facility Type	Mean Length of Stay (months)	Mean Age (Years)	Dementia Type (n)	Baseline Testing Mean Score (Range)	Intervention to Physical Environment Design	Outcome Measures	Key Findings of Environmental Design Interventions
10	Roberts (1999)	Observational; Gerontology/ Nursing	20	Hospital and community setting	No data	No data	No data	CAPE: scoring not provided	Four interventions: • mirror placed in front of exit door • covering doorknob or lock with cloth panel • placing strips of insulating tape in front of exit door • provision of structured day with interest, exercise and companionship	Reduction of exiting	• Use of the mirror appeared to reduce exiting and was most effective for those with severe cognitive impairment (appears to distract from exiting intent) • Doorknob and lock covers less effective for those with moderate/ marked cognitive impairment; tape patterns least effective of the methods used • Floor patterns reduced exiting with some patients but least effective method • Structured day activities proved most successful for those scoring C or above on CAPE scale
11	Kincaid and Peacock (2003)	Observational; Gerontology	12 (2:10)	Dementia care unit in nursing home	36	78	Not specified beyond "diagnosis of dementia" assumed all likely AD given special Alzheimer's care unit	No data	Floor-to-ceiling wall mural painted on double-door entrance/exit, with non-shiny non-reflective Mylar film over door windows to maintain their function and visibility, and with painting extending to the adjacent walls	Counts of 4 types of "door-testing behavior": • calm push/pull of door • patiently wait for someone to enter & attempt exit when door open • team effort (multiple residents attempt to open door together) • exerted force with agitation or hostility	Overall door-test attempts decreased by 42.25 ($t = 2.6$, $p = .024$) after wall mural installation, compared to baseline of 55.67 attempts, a significant decrease. • Two significant findings ($p < .05$) include: reduction in average attempts to calmly test the door ($t = 2.622$) and average number of team efforts in door testing ($t = 2.432$) • The other two types of door attempts also decreased ($p > .05$)

(continued)

Table 1. (continued)

No.	Investigational Study	Research Design; Discipline	n (Male: Female)	Facility Type	Mean Length of Stay (months)	Mean Age (Years)	Dementia Type (n)	Baseline Testing Mean Score (Range)	Intervention to Physical Environment Design	Outcome Measures	Key Findings of Environmental Design Interventions
12	Feliciano et al. (2004)	Observational; Gerontology/ Psychology	1 (0:1)	Adult day-care respite facility	No data	53	"moderate mental retardation, bipolar disorder, and probable dementia"	MMSE 0	Entry-level visual barrier: strip of turquoise fleece cloth matching door color located on the entryway at the participant's eye level. Two test conditions: • interventions were cloth with redirection (gentle physical guidance) • redirection only	Number of door entries and approaches were recorded: • approach: crossing piece of masking tape 0.6 m in front of door without crossing door threshold • entry: crossing the threshold	Door entry behavior was reduced overall by 95%: • the redirection phase showed an entry rate similar to the baseline condition, suggesting that the visual barrier was an important component in reducing door entry behavior; approaches to the visual barrier continued throughout every phase

Cognitive testing: MMSE = Mini-Mental Status Examination; PMSQ = Portable Mental Status Questionnaire; CAPE = Clifton Assessment Procedures for the Elderly; GDS = Global Deterioration Scale

Dementia types (note: nomenclature retained verbatim from studies): AD, SDAT = Senile Dementia of the Alzheimer Type; PD = Parkinson's disease; OBS Organic Brain Syndrome; SD = Senile Dementia; MID = Multi-Infarct Dementia

likely due to visual misperceptions of two-dimensional stimuli.

Hussian and Brown (1987) studied eight older adults with dementia and noted that exit attempts decreased from 98% at baseline with no intervention, to 42% with the addition of horizontal grids created by applying tape to the floor in front of an exit door. Several floor grid configurations using beige masking tape with the final tape 3 ft. (0.91 m) from the end of the hallway were studied, including 3, 4, 6, and 8 strips horizontally, and 10 strips vertically. In addition, eight strips horizontally with the final tape flush with the hallway end were studied. The placement of three, four, or six strips of tape led to a reduction in door contacts, but an eight-strip pattern was more effective than fewer strips tried (this amount was considered more challenging to step over) and had the best effect when not flush with hallway end. The vertical striping was less effective than the horizontal.

In a follow-up study of 10 participants by Hewawasam (1996), a horizontal floor grid was found to reduce exit door contact by up to 97% for those diagnosed with AD. While the horizontal grid pattern was once again found more effective as an exiting barrier compared to a vertical grid, this technique was observed to be most effective in those with AD and less effective in other types of dementia diagnoses (e.g., Parkinson's, vascular dementia). In this study, black tape was used to contrast with the blue vinyl flooring. The authors explain their theory that the horizontal grid pattern is considered unpleasant to look at by generating known visual discomfort (Wilkins et al., 1984). In both studies, the authors conclude that the grid pattern method is relatively safe, economical, and beneficial for caregivers. The horizontal floor grid intervention serves as an unobtrusive stimulus without any unwanted side effects. The authors determine this visual intervention is a positive alternative to other forms of restraint (Hewawasam, 1996; Hussian & Brown, 1987).

In other studies, however, two-dimensional grids either increased or failed to decrease exiting attempts (Chafetz, 1990; Namazi et al., 1989). Chafetz (1990) found no intervention effect with the grid pattern method when applied in front of glass doors, thought to be due to attractive outdoor views that may entice PWD outward—distracting the 30 study participants from the floor grid and/or allowing them to overcome their aversion to these optical illusions. Namazi et al. (1989) tested several tape grid conditions with nine individuals, including horizontal strips of brown tape to provide contrast with the floor, horizontal strips of beige tape posing minimal contrast to the floor, and strips of black tape at a 45° angle to the door and extending out into the hall from the base of the door and partway up the door itself. None of the three tape conditions in this study impeded exiting, which actually increased under these conditions.

A study of eleven PWD living in a dementia care unit showed reduced exiting attempts were not statistically significant with the application of horizontal grid patterns using either black or red tape (Hamilton, 1993). The author postulated that perhaps contrast with both the black and red was "too apparent, meaning that the residents could have been drawn to the patterns on the floor" in comparison to the success of use of beige tape in an earlier study (Hamilton, 1993, p. 59). The windows in the door (similar to Chafetz, 1990) may have also provided distraction and another possible explanation of the results. The floor was also described as having a "high illumination level" at various times of the day which the author notes provided an additional light source and accounted for improved visual acuity and therefore perception. Finally, the door's metallic push bar attracted PWD given its contrast to the door. Several studies noted those with dementia being attracted to the shiny metallic panic bar, often exhibiting the behavior of rubbing/seemingly polishing it, as opposed to an exiting attempt (Dickinson et al., 1995; Hamilton, 1993).

In addition to a grid on the floor in front of the doorway to specifically target and decrease exiting behaviors, placing black floor mats in front of unsafe areas, including doorways, has anecdotally deterred PWD from approaching as these areas are interpreted as holes in the floor (Klosterman, 2014). However, no empirical studies testing this condition were found upon our literature search. See Figure 1a and b for a graphic interpretation of the horizontal and vertical floor pattern interventions.

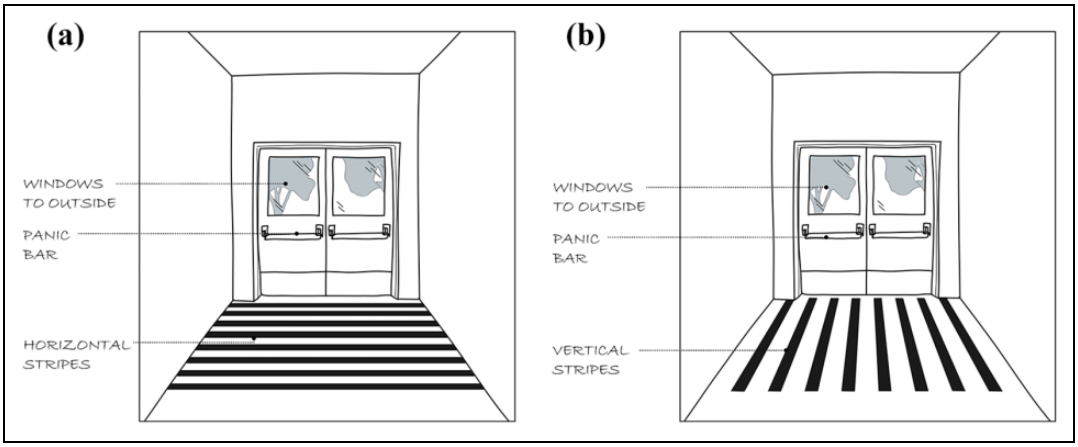

Figure 1. a. Horizontal floor pattern. b. Vertical floor pattern.

Mirrors

Placing a full length mirror in front of an exit door has been shown to reduce exit attempts in PWD (Mayer & Darby, 1991; Roberts, 1999). Mayer and Darby (1991) studied rate of successful exit door contact (including touching, opening or exiting) in nine people living with dementia in a psychogeriatric institutional setting (mean age 77.8 years; MMSE scores of 12 or less) who were designated as "habitual wanderers" (Mayer & Darby, 1991, p. 607). With no mirror, 76.2% of approaches resulted in exit door contact. When the back of the mirror (nonreflective) was used the contact rate fell to 51%. When a mirror was used the rate of door contact was reduced by half (35.7%) compared with no mirror in place ($p < .02$). Of note, although mirror placement reduced the rate of direct door contact overall, approaches to the exit door (recorded when a participant continued towards the exit door and passed a prearranged point, without actual door contact) increased in four of the participants. See Figure 2 for a graphic interpretation of a mirror placed over an exit door.

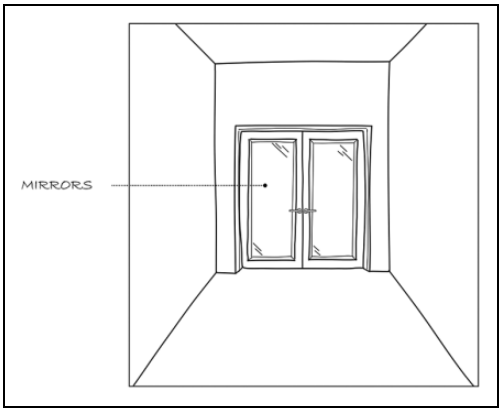

Figure 2. Mirror on door.

Murals

A wall mural painted over an exit door in an attempt to disguise it had a significant decrease in overall door testing behaviors (Kincaid & Peacock, 2003). Kincaid and Peacock (2003) tested the behavioral effects of art with a floor-to-ceiling wall mural painted on a doorway. The mural in this study consisted of an underwater scene and included several fish and a seahorse swimming alongside some seaweed with bubbles. The mural was painted to continuously cover the exit doors as well as adjacent walls. Figure 3 represents a graphic interpretation of this mural's design. Various "door-testing behaviors" were observed: (1) calmly pushing/pulling of the door, (2) patiently waiting for someone to enter and attempt exit when door is open, (3) a team effort (e.g., multiple PWD attempt to open door together), and (4) exerted force with agitation or hostility. There was a significant decrease in total "door-testing behaviors" over six weeks following wall mural installation, compared to baseline

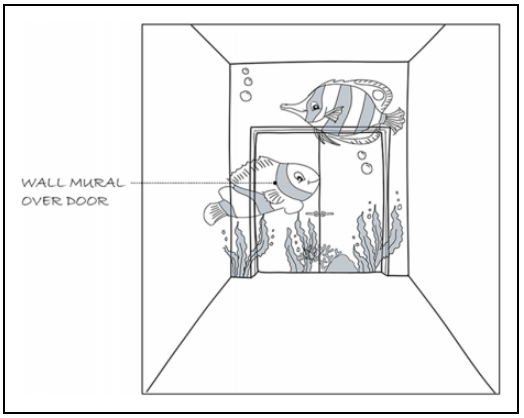

Figure 3. Painted mural over door.

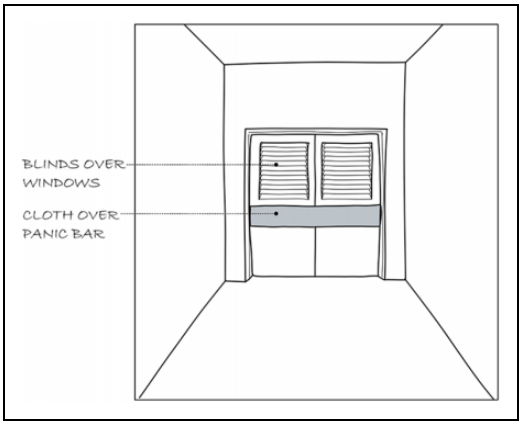

Figure 4. Door hardware and window camouflage.

without the mural. Two significant findings included reduction in average attempts to calmly test the door and average number of team efforts in door testing. The other two types of door attempts also decreased.

The authors speculate that a benefit of this type of environmental cue is that it may have allowed the PWD to experience a sense of control by deciding, without intervention, to turn around and return to other areas. By disguising the doorway, PWD did not need constant redirection from caregivers for testing the doors. That staff did not need to actively redirect PWD from the doorway was thought to foster positive interactions with them. Of note, for one participant, the door testing behaviors actually increased with the wall mural installation. The authors postulated that it may have been due the participant's high cognitive ability based on verbalization of the purpose of the mural and recognition of the painted doorway as a facility exit. See Figure 3 for a graphic interpretation of a mural painted over an exit door.

Door Hardware and Window Camouflage

Additional environmental design strategies studied have included door coverings to conceal door windows and/or door hardware. Namazi et al. (1989) found that the addition of a beige cloth panel to hide the doorknob section of the door was the most successful intervention, eliminating all exiting. This was irrespective of the color or pattern of the cloth cover used (a green patterned cloth intervention was also tested which also eliminated all exiting). Masking the doorknob by painting it the same color as the door to minimize the color contrast and create a camouflage condition and the use of a doorknob cover (allowed the knob to turn only when pressure was applied) were less successful than concealment, but more effective than the use of grid tape patterns.

Dickinson et al. (1995) found that mini-blinds covering the door windows using the same color to match the door was only marginally significant in reducing exiting attempts (exiting attempts decreased from 115 times to 64 attempts: a reduction of 44%). However, the use of a cloth barrier to cover door hardware, similar to the one used by Namazi et al. (1989) to match the door and frame color, was found to be more effective (a reduction of 96% from baseline). Interestingly, the combined use of the blind and the cloth barrier was more effective than the blind alone, but not as effective as just using the cloth covering (a reduction of 88% from baseline). These results support the findings of Namazi et al. (1989) that visual barriers which serve to camouflage the door hardware (panic bar or doorknob) were more successful than other visual interventions tested.

A subsequent study by Dickinson and McLain-Kark (1998) of eight PWD living in a dementia care unit (four with a known diagnosis of AD) with similar interventions found the cloth covering for the door handle to be the most

effective intervention while the mini-blind was not successful. The authors comment that hiding the shiny panic bar on the door dramatically decreased exiting attempts for one participant in particular with multi-infarct dementia, as the "dementia care unit had virtually no visual or tactile stimulation, any contrast within the unit was appealing to this resident" (p. 31). They propose the need for other forms of stimulation such as tactile boards or three-dimensional art.

Roberts (1999) found that while covering the door knob or lock with a cloth panel was successful in many cases, it was less effective for those with moderate to severe dementia. Feliciano et al. (2004) examined the use of a cloth barrier to decrease entry into a restricted area by a developmentally disabled woman with bipolar disorder and probable dementia, resulting in a 95% decrease in entry attempts. See Figure 4 for a graphic interpretation of the door hardware and window camouflage techniques.

Color Cues

Conditioning PWD to respond to colored geometric shapes reduced exit attempts. Three participants with dementia were conditioned to develop negative associations with "supernormal" stimuli—in this case, large, colored, cardboard geometric shapes. Attention to orange cardboard rectangles resulted in the delivery of a favored food item (e.g., sip of cola drink, spoon of applesauce). A blue circle presentation was accompanied by a noxious noise (i.e., a hand clap). When blue circles were placed near exits or potentially hazardous areas (i.e., kitchens, stairwells, elevators), participants walked less towards doors and stairways bearing those images (Hussian, 1982). Of note, the study does not address the ethics around training people to respond to a negative stimulus, which could be distressing despite the inclusion of positive reinforcement.

Discussion

The results of these interior design interventions demonstrate that the environmental experience can impact the behavior of PWD. In their review of therapeutic built environment design for those with dementia, Day et al. (2000) note that design solutions to prevent unwanted exiting do so by "exploiting residents' cognitive deficits" (p. 408). While design interventions are generally implemented as barriers based on known neurophysiological changes in dementia, their intent is rooted in beneficence for maintaining safety.

In brief, the studies we reviewed can be summarized as follows. Horizontal floor grid patterns in front of egress doorways were found to reduce exiting attempts more effectively than vertical tape patterns. In cases where the horizontal grid pattern was not successful, failure was attributed to the presence of glass doors and adjacent windows offering outdoor views. Outdoor views may provide enough of an attractive stimulus to overcome the grid pattern aversion. Door hardware (doorknob or panic bar) may also distract from floor grid patterns, rendering them less effective. Camouflaging the door hardware with a cloth cover, irrespective of the cloth color or pattern, was highly successful at eliminating exit attempts; it was the most successful of all measures. Disguising the doorknob with a knob cover or camouflaging it with paint to blend with the door was less successful. A full-length mirror placed in front of an exit door reduced exit attempts. Painting a wall mural over an exit door to disguise it resulted in a decrease in overall door testing behaviors. Conditioning PWD to avoid colored geometric shapes also reduced attempts to exit or enter unwanted areas when signs were placed there.

Why would these environmental changes reduce exiting behavior in individuals with AD and related dementias when they would not affect healthy persons in this way? While the responsive behavior of walking with purpose is highly correlated with the presence of cortical atrophy (Hussian, 1982), for some environmental changes, the answer is likely related to the diminished visual perceptual abilities of those with dementia. For example, the horizontal floor grid pattern's success as an exiting deterrent is likely due to visual misperceptions of two-dimensional stimuli in PWD. The horizontal grid floor pattern is thought to appear three-dimensional (Hewawasam, 1996; Hussian & Brown, 1987) and perhaps stair-like, thus drawing on these visual perception deficits,

unlike the vertical pattern. Hewawasam (1996) noted the grid technique was most effective with AD and less effective with other types of dementias. Posterior cortical atrophy (PCA), a known visual variant most typically of AD (although also seen in dementia with Lewy bodies (DLB) and other disorders), is characterized by deficits in visual perception, spatial awareness, and has been shown to affect three-dimensional shape processing (Gillebert et al., 2015; Schott & Crutch, 2019). PCA is known to specifically affect the parietal, occipital, and occipito-temporal cortices (Crutch et al., 2012), all of which are typically associated with higher-order visual processing.

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Studies show that even individuals with AD or DLB who do not meet criteria for PCA frequently show impairments in visual acuity, color perception, and texture recognition (Armstrong & Kergoat, 2015; Oishi et al., 2018). The effects of simple visual changes on object recognition in both AD and DLB results in a significant deficit in object recognition and visual identification with changes in viewpoint and texture (Oishi et al., 2018, 2020). These deficits in visual depth perception may explain the altered exiting behavior in response to the floor pattern interventions and the other visual design interventions that we reviewed. Of note, there exists considerable heterogeneity in the dementia symptom profile (Budson & Kowall, 2011), which may explain why some studies found the grid pattern to be less effective.

The mirror intervention is likely effective given the difficulty in identifying reflected self-images which can occur in the setting of dementia (Chandra & Issac, 2014). The authors of the reviewed study postulate mechanisms for the mirror's effectiveness: PWD are often attracted to mirrors, termed "signe du mirror" (Mayer-Gross et al., 1977), and ascribed to the loss of memory and personal identity; a failure of visual recognition whereby it appears as though a stranger is approaching. While this sign has previously been reported in different clinical conditions, it is most commonly seen following cerebrovascular events and in the setting of neurodegenerative diseases, including dementia (Connors & Coltheart, 2011). Parietal function is implicated as those with parietal lobe dysfunction are noted to walk with purpose more than a control group (de Leon et al., 1984).

Namazi et al. (1989) found that camouflaging distinct parts of a door (e.g., a doorknob) reduced exiting behavior in recruited participants with visual agnosia. These techniques are likely successful given that AD can manifest with dysfunction across multiple visual capacities including contrast sensitivity, color discrimination, and depth perception (Budson & Kowall, 2011). The reduced color discrimination capacity found in those with AD when a hue test was administered (Salamone et al., 2009) likely explains the success of the cloth cover regardless of the choice of its color or pattern.

Dickinson and McLain-Kark (1998) note that the best intervention for the exit-seeker is the provision of distracting activities, such as the use of interactive art or other design elements to provide the necessary distraction. Banal medical environments can exacerbate physical expressions of anxiety and experience of frustration, such as repeated exit-seeking attempts (Graham & Fabricius, 2021). Arts-based design interventions, such as a mural, likely reduce exiting attempts through the provision of both diversion and a level of camouflage for door hardware.

During the activity of walking with purpose, behavior is not necessarily random but the ambulation comes under the control of stimuli with reinforcing properties (Hussian, 1982). Although deficits in episodic memory are common in AD and other dementias (i.e., memories of personal experiences), the automatic, unconscious use of procedural memory is separate and distinct, and can be spared (Budson & Price, 2005). The use of stimulus control methodology to reduce wandering was found to be successful (Hussian, 1982), likely due to the preservation of implicit memory.

An alternative to implementing design interventions that serve as barriers to exiting is to accommodate exit attempts in a safe way. When considering the overall building and/or floor layout, positioning exit doors when possible to limit visual access from other areas of the unit (for example, the main communal and circulation spaces) may have a role to play. Similarly, layout may also be used to guide residents towards spaces with more positive and pleasant means of engagement. Chafetz (1990) noted views to the outdoors may serve to attract people towards them. Given that nature views are thought to be inviting to leave a secure dementia care unit, it may be that a landscape/nature mural may not be as effective in preventing door contact and exiting attempts, although this has not been formally studied. Further investigation of color and design in wall murals, in order to attract the attention of PWD rather than discourage exiting has been suggested, in an effort to encourage safe and positive self-directed interactions elsewhere (Kincaid & Peacock, 2003). A significant decrease in agitation was found when doors were unlocked to allow access into secure outdoor spaces (Namazi & Johnson, 1991). Increased autonomy in addition to time outside are thought to have contributed to this finding. In addition, the cultural meaning and/or relevance of a chosen mural may impact how PWD perceive the art.

Limitations

Empirical studies to date included small sample sizes, with all studies reviewed having samples of 30 or fewer participants, and many including fewer than 10. Detailed quality ratings in the form of systematic validation of the identified studies were not undertaken, given that the quality of the environmental design literature on the whole is generally not high. In addition, lack of tools in rating methodologies used in the environmental design literature makes this exercise challenging, although the Forbes approach has been used in a prior systematic review (Fleming et al., 2008). There was an overall lack of information provided for objective cognitive impairment comparison using established scoring systems. In addition, dementia types were not always known. The definition of exit door in terms of immediate adjacencies (for example, whether the door led to the outdoors or an indoor space) was not always clearly described in the reviewed studies. While the rate of research on design and dementia appears to have increased, the empirical evidence on built environment design interventions in the context of exit-seeking attempts was noted between 1982 and 2004, with no studies conducted after 2004. We hypothesize this is attributable to shifts in design concepts for dementia care units focusing on autonomy, home-like settings, and incorporation of accessible outdoor space. However, exits and doorways continue to be prevalent in secured dementia care units, thus we believe the design interventions reviewed here warrant further consideration and study. In addition, given the increasing knowledge around various dementia pathologies and subsequent visual and behavioral sequelae that are specifically related to those pathologies, revisiting prior empirical data may assist in design guidelines and building standards.

Future Directions and Practice Implications

Literature addressing design interventions in the built environment to prevent unwanted exiting for PWD is lacking and outdated. We postulate the lack of recent intervention studies appears to coincide with a shift in dementia design strategies which encourage resident autonomy through purposeful movement through designated paths and outdoor spaces, in addition to smaller-scale home-like settings (Algase et al., 2010; Fleming & Bowless, 1987) and village layouts. In addition, we believe there has been a shift towards addressing the causes of agitation which may lead to walking with purpose and exiting attempts, which in turn has likely de-prioritized the need to engage in some of these ethically questionable design practices. The design of dementia environments that promote a sense of purpose or engagement, while at the same time reducing negative stimuli such as noise, might improve wellbeing and reduce agitation levels and in turn the stress responsive walking that these negative stimuli generate. The preliminary discussion linking

empirical evidence and neurologic mechanisms around design interventions and exiting attempts within dementia care units represents an important step in evidence-based design for dementia care. A further understanding of design interventions based on dementia pathology, in addition to larger prospective study designs, may provide additional design guidance. Interventions may need to be tailored to the specific etiology as well as stage of dementia. Measurement of physiologic metrics, such as electroencephalogram (EEG), heart rate, and/or electrodermal activity readings during exposure to design techniques, may better inform design decisions for dementia care regarding efficacy and potential for adverse reactions, by taking into account patient reactions even when they cannot provide a verbal response to a given design. These biometrics may be also usefully employed to establish the factors in the social and physical environment that may cause any underlying agitation.

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The location of the exits in the care setting is also an important consideration that has not been explored in the reviewed studies. Doors located next to a social space versus at the end of a hallway, for example, may lead to different levels of behavioral outcomes and warrants further study. Finally, general design features such as the size and layout/configuration of the unit, availability of social spaces, and presence/absence of accessible outdoor spaces, are examples of additional architectural features that should be considered in future empirical research in relation to both walking with purpose and exiting attempts in PWD.

Further research may also inform ideal timing of the built environment intervention, including how and when these design elements are introduced for efficacy. For instance, interior design changes (e.g., targeted, colored signage) may be introduced in the environment prior to significant cortical degeneration, to maximize functional learning capabilities. Similarly, repeated exposure to consistent design elements may have potential to reduce any confusion/agitation when confronted by an intervention that is otherwise new to those with dementia.

Conclusions

This review of built environment design interventions to assist in managing the dementia-related behavior of exit-seeking in the context of a dementia care unit demonstrates that design interventions are able to discourage potentially unsafe responsive behavior without restraints or drugs. These methods might be considered part of comprehensive strategies to limit exiting behavior in the setting of dementia care. The observation that these design interventions have varying effects on the heterogeneous subjects indicates a need for more personalized and multimodal approaches to these design techniques. These design strategies likely have widespread application beyond the institutional setting to the home environment as well.

Implications for Practice

Visual barriers which serve to camouflage or disguise egress door hardware (e.g., the panic bar or doorknob) were found to be more successful in experimental studies than other visual interventions tested, including the application of horizontal and vertical floor grid patterns, mirror placement, and painting murals.

Visual design interventions which deter exiting attempts in secured dementia care units are likely successful due to the diminished visual perceptual abilities of those with dementia, including visual misperceptions of two-dimensional stimuli. While these designs have been employed around egress doorways to deter unwanted exiting attempts, knowledge of their effects is useful for designers when implementing interior design schemes in other locations where deterrence may not be a desired effect.

In the experimental studies reviewed, outdoor views were thought to provide enough of an

attractive stimulus to overcome the horizontal floor grid pattern aversion; designs for secured dementia care units can also leverage this effect to promote walking with purpose in appropriate settings as an alternative to implementing design interventions that serve as barriers to exiting, in order to accommodate exit attempts in a safe way.

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