TJTI 1034929
18 April 2015
Revision
CE: GI QA: MG
Coll: SA QC: SN

The Journal of The Textile Institute, 2015
http://dx.doi.org/10.1080/00405000.2015.1034929

The design and initial evaluation of visual cues in carpets to assist walking

Steven J. McNeil* and Laura S. Tapp

Textile Science and Technology Team, Food and Bio-based Products Group, AgResearch Ltd., Christchurch, New Zealand

(*Received 12 May 2014; accepted 13 March 2015*)

Prior research has shown that carpets assist walking thereby reducing the incidence and injury severity of falls, and that visual cues can assist walking. However, little attention has been given to the ability of visual cues in carpets to assist walking. Design guidelines were developed for the colouring and patterning of carpet to provide visual cues to assist walking. The guidelines took into account age-related visual impairments, and were applied in the preparation of a carpet. The designed carpet was compared with two carpets of standard designs in an impaired walking trial. The trial subjects reported a significant preference for walking on the designed carpet, suggesting that appropriate design of carpets can increase their contribution to the well-being of older people and others with impaired walking.

Keywords: carpet design; designing for older people; impaired walking; visual cues; preventing falls

Introduction

The incidence of slip and fall injuries in industrialised countries is increasing as their populations age, since older persons sustain a disproportionately high number of such injuries (Bains, Fok, Marcelo, & Vileshina, 2015; Maki & Fernie, 1990). Injuries caused by falls are a significant cause of hospitalisation; for instance, in the city of Christchurch (population c.a. 350,000); more than 40 older people a week are treated at the Hospital's emergency department for injuries sustained in falls (Mathewson, 2013), and, Langley and McLoughlin (1989) found that injuries caused by falls could account for 25% of hospitalisations. Therefore, ways of reducing the incidence of slips and falls is increasingly important.

One approach to reducing the incidence of falls indoors is to improve the design of floor coverings to increase their contribution to the safe walking of older persons and others. There is a growing recognition that the design of products should empower older people so they can lead independent, dignified and productive lives (Coleman & Myerson, 2001; Durick, Robertson, Brereton, Vetere, & Nansen, 2013; Fisk, 1993).

Carpets are a type of floor covering that make positive contributions to safety and well-being in both subjective and objective ways. Subjective benefits include deinstitutionalising environments, reducing levels of stress and improving aesthetics (Goddin, 1997; Maki & Fernie, 1990; Willmott, 1986; Wise, 1996). The objective benefits of carpets include greater traction (Norton, Fiest, & Orofino, 1995), lower impact forces in walking and falls (Maki & Fernie, 1990; Nabhani & Bamford, 2004), greater comfort during standing (Wu, Pan, & Williams, 2007), ease of maintenance (McCall & McNeil, 2007), improved acoustics (Ford & Bakker, 1984), enhanced thermal properties (Sudnik, 1973), reduced glare (Goddin, 1997), recyclability and biodegradability (McNeil, Sunderland, & Zaitseva, 2007), improved indoor air quality (Ingham, Causer, & McMillan, 1994) and reduced levels of biocontaminants (Foarde & Berry, 2004).

The effect of floor coverings on walking has been documented. For instance, elderly hospital in-patients walked with greater speed and step length on carpet than on vinyl floor covering, suggesting that the patients were walking more biomechanically efficiently and confidently on the carpet (Willmott, 1986). Several studies have shown that carpets reduce the incidence of slips and the injury severity of falls (Hignett & Masud, 2006; Maki & Fernie, 1990; Simpson, Lamb, Roberts, Gardner, & Evans, 2004; Willmott, 1986; Wise, 1996). One study found that more falls occur on carpet than on vinyl floor coverings in hospitals (Donald, Pitt, Armstrong, & Shuttleworth, 2000), but other researchers considered that this study 'had a small sample and the results were not statistically significant' (Hignett & Masud, 2006).

Walking is a complex cognitive task that can be compromised by many factors such as injury and neurodegenerative conditions such as Alzheimer's disease (Buckley, Heasley, Twigg, & Elliott, 2005; Lockhart, Woldstad, & Smith, 2003). Visual impairments are also an important risk factor for falls (Ivers, Norton, Cumming, Butler, & Campbell, 2000), and the significance of visual cues in walking is well established (Amatachaya, Amatachaya, Keawsutthi, & Siritaratiwat,

*Corresponding author. Email: steve.mcneil@agresearch.co.nz

2013; Berard, Fung, & Lamontagne, 2011; Luessi, Mueller, Breimhorst, & Vogt, 2012). Balance disorders are one of the main causes of falls, and people with balance disorders rely heavily on vision to maintain balance and orientation (Redfern, Yardley, & Bronstein, 2001). For example, it has been shown that appropriate visual information can reduce postural instability by as much as 50% (Bunterngchit, Lockhart, Woldstad, & Smith, 2000), and that blurred vision (caused by sensitivity to contrast and glare) induces changes in gait (Buckley et al., 2005). Some people with balance disorders adapt the way they walk by attempting to 'feel' their way across the floor with their feet, and it has been suggested that such adaptations increase kinesthetic information to make-up for unreliable or incomplete visual information (Buckley et al., 2005). Someone who has difficulty keeping their head upright may orientate himself or herself largely using their lower level environment, including floor surfaces (Goddin, 1997; Wise, 1996), thus, increasing both the importance of, and opportunity for, floor coverings to impart visual cues to assist walking.

Little attention appears to have been given to the use of visual cues on floor coverings to improve gait, and thereby help prevent falls (Van Hoof, Kort, Van Waarde, & Blom, 2010). A range of specialist rugs are produced by Carpet Cues, LLC, Corydon, Indiana, USA, for gait and rehabilitation training that utilise visual cues. Suggestions on selecting floor coverings have been included in discussions of designing facilities for older people and sufferers of Alzheimer's disease (Brawley, 1992; Goddin, 1997; Wise, 1996). A study has compared the walking of people suffering from Alzheimer's disease on a set of commercially produced carpets (Perritt, McCune, & McCune, 2005). The carpets had been selected to cover a range of patterns and contrasts between background and foreground. It was found that patterns with large motifs and high contrasts gave rise to the slowest walking and the most changes in gait (e.g. veering, sidestepping and reaching for a handrail). Therefore, this study was conducted to increase understanding in this area, by developing and evaluating a set of design guidelines for the colouring and patterning of carpet that aim to provide visual cues that assist walking of older people and others with impaired vision and/or gait. A carpet was produced using these guidelines, and its impact on walking was compared, qualitatively, with that of carpets with plain and highly patterned designs in an impaired walking trial.

The design of carpet to provide visual cues to assist walking must clearly take into account the vision of the people most likely to suffer falls. Vision declines during ageing, and this may be exacerbated by degenerative eye disease. Visual capabilities can be described in terms of visual acuity, contrast sensitivity, glare sensitivity and colour vision (Haigh, 1993), and it is informative to consider how these change during ageing. Visual acuity is the ability to see fine detail sharply. The ability of the pupil to change shape in response to changing light intensity reaches its maximum in the early teens and progressively diminishes thereafter, reducing visual acuity. Thus, persons over 60 years of age typically need three times as much light as 20 year olds to see the same object (Haigh, 1993). The ability to distinguish between light and dark is known as contrast sensitivity and determines how clearly the outlines of objects are perceived, and more light is required by older people to register the same degree of contrast (Haigh, 1993). Glare results in blurred images, and ageing increases the sensitivity of the eye to glare; consequently, although the ageing eye needs more light to achieve a given level of visual acuity and contrast sensitivity, increased illumination can result in unacceptable levels of glare (Haigh, 1993). The ability to discriminate between blue and green colours begins to decline at around 30 years of age, and around 55 years of age for red and green. These changes in colour vision are caused by progressive yellowing of the eye lens that increasingly filters out more blue and violet light (Haigh, 1993).

When designing carpets to assist walking, the choice of colours and patterning needs to be carefully considered. For instance, colour can play a role in the care of patients with Alzheimer's disease, as patients remember colours more readily than numbers; thus, colour can be used to provide an association with specific areas or corridors (Goddin, 1997), thereby promoting self-navigation. Patients with impaired vision often prefer brighter or more contrasting colours as such colours aid in depth perception and the differentiation of adjacent areas (Goddin, 1997). Lighter shades are desirable as they contribute a greater amount of ambient light (Danger, 1987).

Colours may be divided into two main groups: hard colours (red, orange, yellow) and soft colours (green, blue, violet). Soft colours are more difficult to focus on than hard colours, thus, making them appear to recede and more likely to appear blurred (Danger, 1987). Soft colours should therefore be used for the backgrounds of designs, rather than details, and they should always dominate a pattern. Soft colours also promote mental concentration and are calming, which is why they tend to be the preferred colours for carpets used in aged-care facilities and hotel rooms (Brawley, 1992; Goddin, 1997; Wise, 1996). As hard colours are easier to focus on than soft colours, they appear to advance (Danger, 1987) and should, therefore, be used for the details of patterns.

The appearance of one colour may be modified by another colour within the field of view. For instance, where contrasting colours are placed near to each other,

they will enhance the appearance of each other and will, thus, make the design more prominent (Danger, 1987). Specific colours are less significant than tonality (saturation) in creating contrasts. For example, using a bright, saturated blue with a dull blue may offer more contrast than using a dull blue with a dull red, even though the latter pair are contrasting colours, and the former pair are not. Mixing cut and loop carpet piles of the same tone and hue would define a break within a design, without creating confusion from high contrasts. Contrasting the colours of the carpet and wall would help highlight the edges of the room (Brawley, 1992; Wise, 1996). High contrasts should, however, be avoided, as they may be perceived as holes or steps, especially by those with impaired depth perception, and, thus, cause hesitation in walking (Perritt et al., 2005).

The useful field of view contains the information that can be acquired within one eye fixation, and searching the visual field is a complex process (Ball, Beard, Roenker, Miller, & Griggs, 1988). Environments with visual distractions and clutter that require the use of peripheral vision are difficult to search, even for healthy older adults. The reduced sensitivity of older people to visual and proprioceptive inputs, and their difficulty in handling sensory conflict, hinders their searching of their visual field; thus, increasing the likelihood of falls (Faubert & Bellefeuille, 2002). Therefore, designs for older people should be kept simple so as not to confuse or disorientate (Bunterngchit et al., 2000). Small-scale patterns, particularly soft and non-descriptive ones, are generally preferable to heavy geometrics and spirals that can cause dizziness (Bunterngchit et al., 2000; Goddin, 1997; Perritt et al., 2005).

Materials and methods

Development of design guidelines

Based on the foregoing discussions of walking, vision, colour, patterning and design, seven guidelines were developed for the selection of patterns and colours for carpets to provide visual cues to enhance walking:

(1) Select appropriate colours and saturations. Consider whether the colours can be discriminated by older people and those with impaired vision.
(2) Use contrasting colours without creating harsh contrasts.
(3) Choose light colours to ensure enough light is reflected from the carpet for good visibility, but not so much as to cause glare.
(4) Isolate priority information from background clutter; eliminate irrelevant information and decoration so as not to cause confusion.
(5) Use positioning to communicate importance.
(6) Avoid bold geometric patterns, swirls and any other features that could cause dizziness or confusion.
(7) Choose designs that appear attractive to as many of the users of the carpet as possible.

Design of experimental carpet

Based on the guidelines outlined above, a design was developed for a carpet to be prepared and evaluated. The design combined a plain central walking area with parallel borders of a simple repeating pattern suitable for a corridor/hallway area. There was a desire for some patterning to create depth perception without the design being over-patterned, as this could create disorientation. The plain centre of the carpet design provided a clear and distinctive path for people to walk along. This central area was a mid-blue, a popular colour amongst older people because it is soothing and does not distract (Goddin, 1997). The pattern was designed with the following colours: 12-0822TC, 19-4026TC, 18-3918TC, 19-1530TC and 18-5112TC (Pantone Inc., Carlstadt, New Jersey, USA). See Figures 1 and 2.

Figure 1. Designed carpet.

Figure 2. Designed carpet, border detail.

The borders consisted of a small, straight line to be used as a guideline and a simple repeating pattern in similar tones of blues and greens. Due to common deficiencies in colour vision in older people, the blues and greens chosen would appear similar to them, but would be readily discernible to younger people. Using similar-toned colours minimises contrast, thus, making the pattern less over-powering than would otherwise be the case. Areas of red were added to the border pattern to add more depth to the design. The borders also included some lighter neutral tones, which created an obvious difference between the centre and sides of the border to help to highlight the edges of the carpet.

Preparation of carpets

An ecru carpet was hand coloured using the design described above. Colours were imparted to the carpet by textile dyes (Sandolan MF type, Clariant, Switzerland, kindly supplied by Chemcolour Industries, Auckland, New Zealand) that had been dissolved in ethanol and applied with paintbrushes. Two commercially produced carpets were also used in this study. One was predominately dark-grey with small flecks of blue, ecru and red fibres (Figure 3). This carpet was chosen to represent a plain style of carpet that is widely used in residences and offices in many countries. The other carpet had a dark brown background on which a yellow-brown pattern was superimposed (Figure 4), and was chosen to provide a moderate degree of patterning. This style of carpet is used in entertainment venues and the public areas of hotels. The three carpets had piles of 100% wool in a 6 mm high, loop construction which is a common design for carpets intended for residential and commercial installations.

Figure 4. Patterned carpet.

Evaluation of carpets

The three carpets were cut to the same size (1 m × 4 m) and placed parallel to each other with half a metre between them (Figure 5). Laboratory walking trials were conducted with 20 healthy adult subjects (10 female and 10 male) aged between 18 and 50 years (Worsfold & Simpson, 2001). Subjects were not asked whether they had any gait, balance or visual impairments, but all held current driver's licenses. Following the approach of Ishihara, Ishihara, Nagamachi, Hiramatsu, and Osaki (2001), the subjects wore a face shield with a yellow lens (Figure 6) to simulate the vision of a typical 80 year old in terms of colour discrimination and contrast sensitivity (Haegerstrom-Portnoy, 2005). The visible light transmittance through the face shield was measured by a spectrophotometer (CARY 1, Varian, Australia) and shown in Figure 7. The face shield was in place before the subjects saw the carpets for the first time. The trials

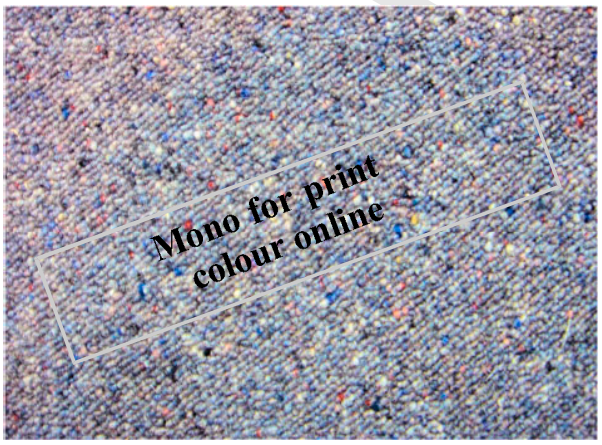

Figure 3. Plain carpet.

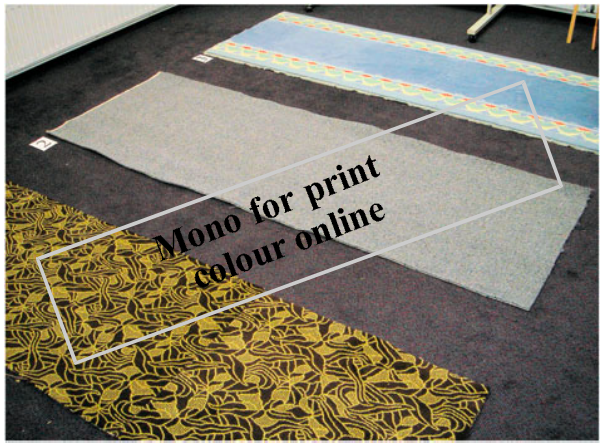

Figure 5. Carpets in position for walking trial.

Figure 6. Face shield worn by subjects in walking trial.

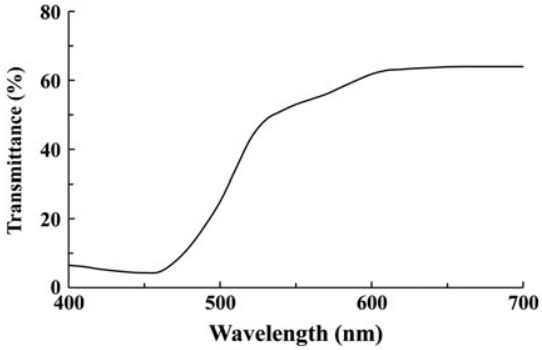

Figure 7. Light transmittance through face shield.

were conducted under fluorescent lighting, at levels typical of an office.

After viewing the carpets, but not walking on them, the subjects were asked a series of questions about the carpets related to their designs, colours and their likely ease of being walked upon. This questioning was undertaken as the level of confidence a person has in their ability to walk on a surface, makes a significant impact on their subsequent walking (Newell, VanSwearingen, Hile, & Brach, 2012).

The subjects then walked slowly and continuously once in each direction over all three carpets, in turn, and were then immediately questioned about their perceptions of the walking. The arrangement of the carpets was randomised for each subject. Some gait instability was introduced during walking by requiring the subjects to carry a light load. Bunterngchit et al. (2000) have shown that carrying a light load affects both stride length and minimum toe clearance during walking. The load employed in the study reported here was a cardboard box (1 kg, 60 cm long, 30 cm wide and 15 cm high) that was held with two hands at waist height, with its long axis perpendicular to the direction of walking. The box obstructed the subjects' immediate views of the floor, reduced their arm movements, and reduced the amount of attention they could devote to the task of walking.

When subjects were asked to compare carpets, the responses were analysed for statistically significant differences by the Friedman method, adjusted for ties (Minitab® 16.2.2, Minitab Inc., State College, Pennsylvania, USA). From each subject's response to each question, the three carpets were given rankings as follows: 3, 2 or 1, respectively, for the highest to lowest ranking; where two carpets were judged the same, they were both ranked as 1, if equally low, or 3 if equally high; if all three carpets were judged equally high they were all assigned 3s; if none of the carpets were chosen, they were all assigned 1s. Where the null hypothesis (sums of rankings of each carpet are the same) was rejected ($p < 0.05$), *post hoc* analysis was performed by determining the least significant difference (two sided, 95% confidence) (Bortz, Lienert, & Boehnke, 2000).

Results

The responses of the trial subjects to questions asked after their initial view of the carpets, and after walking on the carpets, are reported in Tables 1–5. The results of the statistical analyses are shown in Tables 6 and 7.

Discussion

Fifteen of the twenty subjects described at least one of the carpets as overpowering (Table 1). Fourteen subjects reported the patterned carpet was overpowering, compared to two and one for the designed and plain carpets, respectively. Five said that none of the carpets were overpowering, and one thought all of the carpets were overpowering. The patterned carpet was significantly more overpowering than the other two, for both females and males. Nineteen of the subjects reported that the patterned carpet appeared busier than the others did, while one subject reported that the designed carpet was busier than the others (Table 1). The perceived busyness of the plain and designed carpets was not significantly different from each other (Tables 6 and 7). The busyness of the patterned carpet was ascribed to the scale of the pattern, the degree of contrast and a three-dimensional effect. The subject (female, number three) who described the designed carpet as the busiest ascribed this to the presence of edges in the design. There was a stronger perception of busyness than of being overpowering. All of the female subjects and seven of the male subjects reported that at

Table 1. Initial impressions of the patterning of the carpets[a].

	Do any carpets have an overpowering pattern? If so which one(s)?		Does one carpet seem busier than the others? Which one(s)?		What is it about the pattern that makes one carpet seem busier than the others?	
Subjects	Female	Male	Female	Male	Female	Male
1	1	1	1	1	Colour, contrast, scale too big	Small and repetitive
2	3	1	3	1	Edges	Type and scale
3	1	No	1	1	All lines in different directions, asymmetry	Type
4	1	1	1	1	Colour contrast	Repeats too quickly. Too much contrast making it look three-dimensional
5	1	No	1	1	Type, swirly, large-scale	It looks winding
6	1, 2, 3	1	1	1	It weaves and swirls, strains the eyes	Scale and contrast
7	No	1	1	1	Scale	Type, dark, perceived depth
8	No	1	1	1	Scale	Not restful, no colour, high contrast, scale
9	1	No	1	1	Scale, type, swirly, three-dimensional	Size, contrast, colours
10	1	1	1	1	Like a maze	Scale, too much repetition

[a]1 – Patterned carpet; 2 – Plain carpet; 3 – Designed carpet.

Table 2. Initial impressions of the colours of the carpets[a].

	Do any of the carpets use colours that are hard to discriminate?		Which, if any, colours are hard to discriminate? Comments?	
Subjects	Female	Male	Female	Male
1	1, 2	1	Looks plain	Not much difference between any
2	2	3	All one colour	Blues and greens only subtlety different
3	1	No	Murky	N/A
4	3	No	Greens and blues similar	N/A
5	2	3	Mottled	Blues and greens
6	3	No	More subtle colouring in border	N/A
7	2	2	All one colour	Just one colour
8	2	3	One block of colour	Subtle difference between green and blue
9	3	3	Greens and blues	Three or four of them
10	2	2	Muted, mucky	Mottled white/green

[a]1 – Patterned carpet; 2 – Plain carpet; 3 – Designed carpet.
N/A – Not applicable.

least one of the carpets had colours that were hard to discriminate, but the differences between the carpets were not significant (Tables 2, 6 and 7).

Sixteen subjects thought the patterned carpet would be the hardest to walk on (Table 3), which is significantly more than the three who nominated the plain carpet, and the one who nominated the designed carpet, supporting the view that such bold patterns should be avoided (Brawley, 1992; Goddin, 1997; Perritt et al., 2005; Wise, 1996). Fourteen subjects thought the designed carpet would be the easiest to walk on, considerably more than the numbers who thought this about the plain (four subjects) or patterned (one subject) carpets (Table 3). This finding suggests that the guidelines developed here produced a carpet that looked as if it would be easy to walk on, which could, thus, be expected to increase the confidence of walking (Newell et al., 2012).

Nine of the twenty subjects in the walking trial said that they found at least one of the carpets overpowering to walk on; seven said that it was the patterned carpet, and two said that it was the plain carpet (Table 4). Males did not report a significant difference between the three carpets in terms of being overpowering (Table 7).

Table 3. Conjectured ease of walking on the carpets[a].

	What carpet do you think would be the easiest to walk on? Why?		What carpet do you think would be the hardest to walk on? Why?	
Subjects	Female	Male	Female	Male
1	3-looks plush	3-clearly defined line down middle	2-colour contrast	1-appears random, no clear line aspect
2	1-looks warm, not right in your face	2-no distractions	2-looks dull and flat	1-uneven, three- dimensional
3	3-directive	2-plain, smooth	1-could interfere	1-too busy
4	3-guidelines	3	1-too busy	1-would make people hesitant, waiting for something to happen
5	3-strip up middle which guides	2-clear	1-too busy	1-pattern all over, too busy
6	2-plain	3-pleasant to look at, not too busy in middle	3-I would try to keep within the margins	1-strains eyes, too busy
7	3-shows direction	3-guides	1-too much happening	1-confusing
8	3-plain centre, guidelines on edges	3-nicer to approach, nice plain strip, pattern guides	1-pattern looks three-dimensional	1-pattern makes you sick
9	3-rails to follow	3-clearly defined borders to follow	1-very busy, takes attention	2-plain shade, no indication of position
10	3-tramlines	3-parallel lines guide	1-strikes eyes, detracts	1-trouble with depth perception

[a]1 – Patterned carpet; 2 – Plain carpet; 3 – Designed carpet.

Table 4. Perceptions of the carpets after walking on them[a].

	Did you find any of the carpets overpowering to walk on? If so which one(s) and why?		Which carpet(s) used pattern or colour that helped you walk easily? If so, which one(s)?		How did patterns or colours help you walk easily?	
Subjects	Female	Male	Female	Male	Female	Male
1	1	No	None	3	N/A	Clear strip, linear
2	No	No	3	None	Borders guided	N/A
3	No	No	3	3	Borders and definite contrast	Borders
4	No	1-noisy, distracting	3	3	Keeps you in the middle	Walking in a lane
5	No	No	3	3	Guidelines to walk between	Border pattern guides you
6	1-pattern interferes	No	3	3	Keep in middle easier	Slightly, running pattern guides
7	1-pattern too swirly	2	3	3	Guidelines, plain centre	Good pattern, repeat in direct walkway
8	1	1-contrast and scale of pattern	3	3	Borders guided	Borders guide, and centre plain
9	1	2	3	3	Pattern lines to follow	Straight lines, edges
10	No	No	3	None	Plain centre guides	N/A

[a]1 – Patterned carpet; 2 – Plain carpet; 3 – Designed carpet.
N/A – Not applicable.

In contrast, females found the patterned carpet to be significantly more overpowering than the other two (Table 6). This was the only carpet attribute where only one gender reported a significant difference between carpets.

Seventeen subjects reported that at least one of the carpets used pattern or colour that helped their walking, and in each case, it was the designed carpet. The subjects variously attributed the easier walking on the designed carpet to a feeling of walking in a lane, being

Table 5. Overall preferences for the carpets[a].

	Overall, what carpet do you think is the most suitable to walk on?	
Subjects	Female	Male
1	3	3
2	1	2
3	3	3
4	3	3
5	2	3
6	2	3
7	3	3
8	3	3
9	3	3
10	3	3

[a]1 – patterned carpet, 2 – plain carpet, 3 – designed carpet.

given guidance to stay in the centre, and the manner in which the pattern repeated in the direction of walking without being cluttered with detail. The subject who thought that the designed carpet would be the hardest to walk on (female, number six, see Table 3) found that in practice, this carpet had a pattern or colour that helped her to walk easily.

The designed carpet was reported by 16 subjects as being the most suitable to walk on, which is significantly more than the other carpets (Tables 5–7). The carpet that was perceived to be the next most suitable for walking on, was the plain carpet (identified by two subjects). One subject (female, number three) reported that the patterned carpet was the most suitable for walking on, having reported that the designed carpet had an overpowering pattern (Table 1). However, the difference between the patterned and plain carpets was not significant (Tables 6 and 7).

The responses made before and after walking on the carpets were largely in accord, indicating that walking on the carpets coincided with the subjects' expectations. The results of this walking trial are consistent with the findings of Perritt et al. (2005) and support the design guidelines developed in this study and those put forward by Brawley (1992), Wise (1996) and Goddin (1997).

Table 6. Statistical analysis of the results for female subjects.

	Sums of carpet rankings			p[b]	LSD[c]
Question[a]	C1	C2	C3		
Pattern looks overpowering? Table 1, part 1	24	12	14	0.012	9
One carpet looks busier than others? Table 1, part 2	28	10	12	0.001	6
Colours hard to discriminate? Table 2	14	22	16	0.273	N/A
Carpet looks easiest to walk on? Table 3, part 1	12	12	26	0.002	8
Carpet looks hardest to walk on? Table 3, part 2	24	14	12	0.045	9
Carpet was overpowering to walk on? Table 4, part 1	20	10	10	0.007	7
Carpet design assisted walking? Table 4, part 2	10	10	28	0.000	4
Most suitable carpet to walk on? Table 5	12	14	24	0.045	9

[a]Questions in highly abbreviated form, see Tables 1–5 for full questions.
[b]Probability of the null hypothesis being true.
[c]Least significant difference of the sum of carpet rankings.

Table 7. Statistical analysis of the results for male subjects.

	Sums of carpet rankings			p[b]	LSD[c]
Question[a]	C1	C2	C3		
Pattern looks overpowering? Table 1, part 1	22	10	10	0.002	7
One carpet looks busier than others? Table 1, part 2	30	10	10	0.000	0
Colours hard to discriminate? Table 2	12	14	18	0.368	N/A
Carpet looks easiest to walk on? Table 3, part 1	10	16	24	0.025	9
Carpet looks hardest to walk on? Table 3, part 2	28	12	10	0.001	6
Carpet was overpowering to walk on? Table 4, part 1	14	14	10	0.368	N/A
Carpet design assisted walking? Table 4, part 2	10	10	26	0.000	6
Most suitable carpet to walk on? Table 5	10	12	26	0.001	7

[a]Questions in highly abbreviated form, see Tables 1–5 for full questions.
[b]Probability of the null hypothesis being true.
[c]Least significant difference of the sum of carpet rankings.

Conclusions

The design guidelines that were developed for the colouring and patterning of carpet were shown to assist the walking of subjects with induced gait and vision impairments. These findings can be applied by carpet designers, and those who buy or specify carpets, particularly for installations that will be used by older people or those with impaired gait or vision. The results of this study support the view that appropriate design can increase the contribution of carpets to the well-being of the increasing number of older people in society. Further work in this area is warranted to test the findings of the small qualitative study reported here and enhance the design guidelines developed. For instance, using a population of older adults with a range of known visual and balance impairments would permit the identification of any benefits from particular carpet designs, and it would be useful to determine the effect of changes in lighting. Quantitative measures could usefully be made of any changes to walking patterns such as walking speed or path deviations (Perritt et al., 2005; Willmott, 1986) induced by the designs of carpets.

The practical implication of the study reported here is that carpets can be designed with colours and patterning that provide cues that assist walking. Thereby, they contribute to reducing the incidence of falls in the indoor environment.

Acknowledgements

L.S.T. gratefully acknowledges funding from the New Zealand Foundation for Research Science and Technology for a Technology in Industry Fellowship. The authors would like to thank Larissa Zaitseva and Sam Leighs for assistance with photography, and Warren Meade for his encouragement to work in this area.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Steven J. McNeil http://orcid.org/0000-0003-1664-9667

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