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**Manipulating the appearance of steps and stairs to make them safer for
older people to negotiate**

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Manipulating the appearance of steps and stairs to make them safer for older people to negotiate

1. Aims/Objectives:

To determine whether simple modifications of the appearance of steps and stairs can make them safer for older people to negotiate.

2. Background:

Clearly falls, including falls on stairs, are a major problem for older people. We know that vision plays a major role in successful stair negotiation and propose that simple modifications to the appearance of stairs could make them safer for older people. Given the importance of the step edge in trips and falls on steps and stairs, highlighting the step edge is a logical safety strategy. In previous work we have shown that with uncertainty regarding the step-edge location, increasing foot clearance is a particularly important safety strategy in both step ascent and descent. Moreover in a pilot study we have demonstrated that foot clearance during step ascent can be increased using a version of the horizontal-vertical illusion superimposed on a step. The proposed studies will determine whether the use of this approach can make steps and stairs safer for older people during both ascent and descent.

3. Need:

The National Service Framework for Older People has made reducing the number and severity of falls a specific Government target and a variety of interventions for older people have been and are being assessed. At least 500-600 deaths a year and an injury every 80 seconds occur as a result of a fall on steps or stairs in the UK. Safety modifications to stairs could significantly reduce these figures. Avoidance of hip fractures could also reduce the number of people losing independence, quality of life and being admitted to a nursing home. Falls and hip fractures are mentioned as a contributing factor in 40% of admissions to long-term nursing and residential home care. Finally, even a reduction in non-injurious falls could have significant benefits by reducing the number of older people in fear of falling, with self-imposed restriction of functional activity, lost mobility, independence, poor health and quality of life and depression.

4. Methods:

a. Setting

The gait and vision laboratory at the University of Bradford.

b. Design

A repeated measures laboratory based study, investigating adaptive gait in independently mobile older people.

c. Data collection

Adaptive gait when ascending and descending steps and stairs will be assessed with and without a variety of modifications to the appearance of both single and multiple steps. The analysis of step/stair ascent will primarily focus on foot placement relative to the step riser, toe clearance over the step edge, and foot placement on the upper step or raised surface. The analysis of step descent will primarily focus on heel clearance over the edge or nosing, heel placement distance on the lower step's tread, pre-landing kinematics for the descent phase and the mechanics of landing for the initial contact period. Existing 'in-house' analysis software that uses previously developed (and reported) biomechanical modelling approaches will be employed to investigate how gait parameters, toe and heel clearance and landing behaviour are adapted under the visual illusion. In addition, we need to determine whether a mismatch between step height as perceived visually (5-20% higher than actual size) and that perceived via the somatosensory system once the lead-foot has landed on the top of the step, could unsettle postural stability, particularly for the larger increases in visually perceived step height. If this occurred, it could negate any improved safety gains from the increased toe clearance of

the step edge. For this reason we intend to also determine the effects of the different illusions on dynamic postural stability, by determining the anterior-posterior (A/P) and medio-lateral (M/L) distance between the lateral malleolus of the leading foot and the centre of mass (COM) and the A/P and M/L COM velocity at the instant of foot contact. It is likely that toe and heel clearance will reduce as subjects ascend and descend the stairs and we need to determine whether this learning effect is changed in any way due to the visual illusion by assessing the effect of trial repetition.

d. Data analysis

Data will be analysed using a random effects population averaged model, using the Stata version 9.2 statistical programme (Stat Corp., College Station, USA). This multivariate model will be obtained using the Generalised Least Squares (GLS) random effects estimator, which produces a matrix-weighted average of between-subjects and within-subjects results. An exchangeable correlation structure was judged to be appropriate, given the experimental design, and due to the exploratory nature of the study no 'type I' error adjustment of the alpha level is deemed necessary. Thus level of significance will be set at $p < 0.05$. Factors of interest will be incorporated sequentially and their statistical significance tested using a likelihood ratio test. Factors with a p-value less than 0.10 will be provisionally retained, whereas those above 0.10 will be dropped. The final model adopted will be the most parsimonious one felt to adequately explain the data.

5. Contribution of existing research:

British Standards for stairs construction have existed since 1944 and the current code of practice is incorporated in BS 5395-1:2000, with an update of this Standard imminent. This provides guidelines for the construction of stairs in terms of the riser, going, pitch, headroom and handrails and it is likely that improved stair design has improved stair safety. In addition, various approved documents in UK Building Regulations pertain to stair design, including approved documents K (Protection from falling, collision and impact, 1998 edition), M (Access to and use of buildings, 2004 edition) and B (Fire safety, 2006 edition). Several recommendations have been made regarding improving safety on stairs to reduce the number of falls, particularly in the US, but the majority of them are not evidence-based and, importantly, little attention has been paid to whether these general guidelines are optimal for the older stair user. Because of the important role of vision in the successful negotiation of stairs, several recommended safety modifications have included changes to the appearance of stairs. These include making the tread surface a uniform colour and adding a single contrast strip 25-38 mm (1-1.5") wide that is mounted flush with the surface and placed close to the edge of the step or that it is 50-75mm wide with 30% luminance contrast and not set back more than 15mm from the nosing (Australian Standard 1428) or a guideline for stair nosings (in this case referring to a shield that covers the edge of a step or stair tread) to be 55mm wide on both tread and riser with a luminance contrast of at least 30% compared to the rest of the step (UK Building Regulations, approved document M). These guidelines do not appear to be based on any research evidence. Indeed, the only research that has considered the effect of a step edge highlighter to date found no significant effect of a 1.5 inch (~38mm) strip in a 5-step descent experiment for 36 healthy older women. However, measurements were made in the mid-stair portion of step descent where trips and falls are least common and the participants were relatively young (mean 60.8 years) with good visual acuity of better than 6/9.

6. Plan of Investigation:

Measurable objectives include the following:

- 1) To determine whether a step edge highlighter improves the safety of adaptive gait during step descent.
- 2) To determine the optimum spatial parameters of visual texture for such a step edge highlighter.
- 3) To determine whether a step edge highlighter set back from the step edge decreases the safety of adaptive gait.
- 4) To determine an optimal version of the horizontal-vertical (H-V) visual illusion, for older individuals, that when superimposed upon a step, make it appear taller.
- 5) To determine whether increased perceived step height leads to a corresponding increase

in toe clearance for older adults.

- 6) To determine whether the use of an optimised H-V illusion on either the first, top and bottom or all steps of a three-step stairway improves the safety of adaptive gait.

7. Project Management:

Professor Elliott (PI) will have overall responsibility for the project, including writing annual progress reports to EPSRC. Professor Whitaker will provide expertise on visual illusions and will take a lead role for experiment 1. Dr Buckley will provide biomechanical and gait/motion analysis expertise and Mr Scally will guide statistical analysis. Mr. Roys will act as a consultant for issues relating to British Standards and Building Regulations. Regular meetings of the research team will discuss and finalise technical and methodological issues, data interpretation and the writing-up of findings. The PDRA will be expected to look after 'day-to-day' operation of the laboratory and will conduct all data collection.

8. Service users/public involvement:

Members of the public regularly help direct our research. A group of about 50 retired volunteers act as volunteer patients for our undergraduate optometry students to perform eye exams and this group is added to on a regular basis, particularly from the 200-strong Bradford Older People's Forum. Volunteers from these groups are regularly asked to help in pilot studies and focus groups (we are also involved in questionnaire-based quality of life studies). For this particular series of studies, we asked several volunteers to help determine the safety and feasibility of using a 3-step system for step ascent and descent as most of our previous adaptive gait experiments had mainly used one step. Other labs have used a multi-step stairway, but this has necessitated the use of a harness system to ensure participant safety, which can make the experimental set-up less like using stairs in the 'real world'. Given that a third of accidents tend to occur on the first or last step and 70% occur in the first three or last three steps, we considered the use of a three-step system without safety harness for the proposed studies.

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