The division of visual attention affects the transition point from level walking to stair descent in healthy, active elderly adults.

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ABSTRACT

Background: Stair descent is a frequent daily activity that poses great risks for injury due to falling. Very little is understood about the attentional demands of stair descent and their changes with aging. The present study compared combined locomotor and cognitive functioning during different phases of stair descent between healthy young and older individuals.

Methods: Sixteen young and sixteen healthy older subjects walked down a 5-step staircase, performing a simultaneous visual Stroop task during the approach, transition and steady state descent phases of stair descent (i.e., a dual task) in some trials. Three dimensional kinematics of trunk and foot motion were recorded along with the accuracy and dual task costs (DTCs) for responses to the Stroop stimuli.

Results : Dual tasking influenced both gait and cognitive performance for all subjects, and older adults generally walking slower with higher foot clearances and had greater DTCs. Specific age differences were found at stair transition where older adults showed more attentional affects.

Conclusions: Healthy, active older adults showed changes to attention and planning due to normal aging specifically associated with a crucial point of fall risk for stair descent.

RESEARCH HIGHLIGHTS

- We compared combined locomotor and cognitive functioning during stair descent between healthy older and young adults
- Dual tasking influenced both gait and cognitive performance for all subjects
- Older adults show more attentional effects at the transition to stair descent when fall risk is greatest

KEYWORDS

Dual task, stair descent, elderly, executive function

ABBREVIATIONS

DTCs = Dual Task Costs

1. INTRODUCTION

Stair gait is a frequent daily activity with great potential risk for falls and injuries (Bridenbaugh and Kressig (2011)) Chu et al. (2012)). Stair descent particularly poses a great risk for falling for older adults (Bosse et al. (2012) Hamel and Cavanagh (2004) Startzell et al. (2000) Verghese et al. (2008)) and nearly sixty percent of falls on stairs occur during transition on the first or last two steps (Jackson and Cohen (1995)). Although the reasons for this increased risk for stair descent with age may in part be due to decreased muscle strength (Bosse et al. (2012)), given the complex integration of different musculoskeletal, cognitive and psycho-social factors when descending stairs, it is more likely the result of a general functional decline (Startzell et al. (2000) Verghese et al. (2008)).

Based on observations for obstacle avoidance (Mohagheghi et al. (2004) Patla and Vickers (1997)), planning and visual attention for surface transition takes place during the approach to the obstacle and not during the actual transition execution. Miyasike-daSilva et al. (2011) found that, like obstacle avoidance, visual attention is given to the transition steps during approach, but there appears to be very little foveal attention (gaze fixations) on the transition steps when actually descending them. The authors suggested that foveal vision is important to acquire information a few steps ahead, while peripheral vision may be important for limb trajectory control. During steady-state stair descent, gaze is generally fixated at least 3 steps ahead (Den Otter et al. (2011) Zietz (2009)). Overall, these recent findings support the need for visual anticipation and planning during the approach to stair transition with perhaps decreased attention for actual transition for at least young adults.

In everyday environments, as for other locomotor tasks, stair descent is rarely performed in isolation and also requires dividing or switching attention in order to perform simultaneous tasks.

Such multi-tasking is, of its own right, a source of risk for falls in older adults (Hsu et al. (2012) Beauchet et al. (2009) Chu et al. (2012) Herman et al. (2010)) and older adults generally show greater dual task effects that are environment and task dependent, whether due to increased caution, decreased physical and cognitive function or both (Woollacott and Shumway-Cook (2002)). Yet, to our knowledge, few studies have used the dual task paradigm with stair gait and particularly for decent where inattention from everyday stimuli has a heighten risk of leading to serious injury or even death. Miyasike-daSilva and McIlroy (2012) recently found that even though foveal visual information of the transition to stair gait was not necessary, the transition steps involved increased demands in executive functioning. It was suggested that dividing visual attention narrowed one's focus away from peripheral information important to the transitional step, therefore, making the transition step more demanding. Using an auditory Stroop task, Ojha et al. (2009) showed that healthy, elderly subjects had longer response times for steady-state stair walking (ascent and descent) compared to younger subjects. They did not look at transition, but given this changed attentional capacity with aging, we might expect all aspects of stair decent to be more demanding of their visual attention, particularly for stair descent where the risk for falls is greater. Thus, from the brief literature available, we might expect stair descent to require more visual attention for older adults (even at transition and steady state) and thus be specifically interfered with by other simultaneous visual tasks found daily in the home and public environments (e.g., other people, signage, etc).

The purpose of the present study was to compare combined locomotor and cognitive functioning between healthy young and older individuals during the approach, transition and steady state phases of stair descent. The specific hypothesis was that normal aging would result in changes in the ability to perform simultaneous visual tasks related to greater response costs as well as modified gait fluidity and greater foot clearance for the older adults. The present focus is specifically during the periods of level to stair transition as well as during steady state descent, both when less attention should be required.

2. MATERIAL AND METHODS

2.1 Participants

Sixteen healthy young (24.81 ± 3.95 years; eight women) and sixteen healthy older (70.38 ± 5.88 years; eight women) community-dwelling adults were recruited. Exclusion criteria included self-reported history of falls, physical, neurological or cardio respiratory problems, walking speeds less than 1 m/sec; and age specific cognitive impairments. Eyeglasses or contact lenses were used if needed and participants were required to have minimal scores on the Snellen Chart Test of 20/30. All participants provided written consent and the study was approved by the Ethics review board of the Quebec Rehabilitation Institute.

2.2 Clinical assessment

Screening: Screening was first carried out with an initial telephone contact to exclude for general musculo-skeletal, neurological and cardio-vascular criteria, followed by a first visit where older subjects were screened to exclude for abnormal cognitive function for age and educational level Blanchet et al. (2002) Petersen et al. (1999) based on performance at least 1.5 Standard Deviation below standardized average values for memory tests and on one or more other cognitive tests thus accounting for both single and multiple domain amnestic and nonmemory MCI. Further testing included general cognitive functioning (Mini-Mental State Examination, Folstein et al. (1975)), episodic memory in verbal (California Verbal Learning Test, Nolin

(1999) and visuo-spatial (Visual Reproduction of Wechsler Memory Scale,Wechsler (1997) modalities, attention and executives processes (Digit symbol ofWechsler Adult Intelligence Scale, (Wechsler, and Category Fluency from the Delis-Kaplan Executive Function System,Delis et al. (2001) , visuo-spatial processes (Copy of the Osterreith-Rey Figure,Rey (1959) Benton Judgment of Line Orientation,Benton et al. (1978) and finally language functions (short version of the Boston Naming Test,Kaplan et al. (1983)). During this first screening visit, functional walking speed was also evaluated.

Neuropsychological tests: If deemed eligible, all the young and older individuals performed further neuropsychological tests in a subsequent visit assessing cognitive functions expected to be involved in the experimental task related to planning (Wisconsin Sorting Card Test Resources (2003) , working memory Belleville et al. (1992) , short-term memory (Brown Peterson Paradigm (Belleville et al., 2002), attentional switching processes (Trail Making Test from the Delis-Kaplan Executive Function System Delis et al. (2001) , inhibition processes (Stroop from the Delis-Kaplan Executive Function System Delis et al. (2001) and sustained and selective attention (Conners' Continuous Performance II Conners (1995) . Assessments of physical ability and falls efficacy were also tested at this second visit. These physically based tests included: the Activities Confidence Balance Scale for falls efficacy (French version; Filiatrault et al. (2007) ; the Baecke Physical Activity Questionnaire for activity levels Baecke et al. (1982) ; the Berg Balance ScaleBerg et al. (1989) ; the walking section of the Tinetti test Tinetti (1986) ; and comfortable and maximal speeds over 5 meters. Screen test, as well the laboratory tests described below were performed on separate days to avoid fatigue.

2.3 Experimental Protocol (laboratory tests)

During a third visit, subjects descended a five step staircase with average riser heights of 19 cm, tread depths of 30 cm and 102 cm wide (Chapdelaine et al. (2005) ; see Figure 1). The top step was also a platform (102 cm x 244 cm) used for the approach to descent. Handrails made of hard wood (2.9 cm in diameter) were available on both sides, each with a height of 83 cm from the nose of each step. Subjects wore comfortable walking shoes a T-shirt and shorts as well as a harness attached by a rope, the length of which was controlled by a trained experimenter through a belay mechanism that could be immediately locked in the case of a fall. Room lighting was controlled to be between 726 and 787 lx at the level of the first edge at the top step. Kinematic measures were collected using an Optotrak system (model 3020, NDI; 50 Hz) with three infrared sensor bars (one in front of the staircase and two at the sides). Triads of noncollinear infrared markers were placed on each subject's head, trunk, wrists, pelvis, thighs, shanks and feet. Only the trunk and feet segments are presented here. Specific anatomical points were also digitized in order to define principal axes of each targeted segment. In addition, an average of 90 points were digitized on the soles of each shoe in order to create a 3D surface used to calculate minimal foot clearance Telonio et al.) . Verbal responses to the cognitive task (described later) were recorded (1000 Hz) through a microphone worn by the subjects.

The simultaneous visual Stroop task, required participants to name as quickly as possible the color of the ink of a single word (red, green or blue) and to ignore the lexical meaning of the word which was always incongruent. Words were projected simultaneously for 1 second on four computer monitors placed at the bottom of the staircase allowing subjects to maintain the staircase within their field of view. Both the fluidity of descent and speed of response were prioritized (see instructions below). Base-line Stroop task performances while sitting were also administered before and after stair descent. In these tests, twenty words were presented at a rate of 1 Hz with practice allowed before.

Participants first descended the staircase 5 times without any simultaneous task (not analysed). Subsequently, subjects descended during 4 different conditions (unannounced), 5 trials each, presented in random order for a total of 25 trials. These conditions included 1) no Stroop task (single task (ST)); or a dual task (DT) when a single Stroop stimulus was presented 2) on the first step (step 0) during approach to descent; 3) at the transition to descent beginning at foot contact at the edge of the top platform (or contact of step 2); or 4) during steady state descent at foot contact on the second step down (or contact of step 3). The first two Stroop stimuli were triggered by light beams appropriately placed on the top platform and adjusted for step length differences between subjects for the first step. The stimulus in steady state descent was triggered by a force platform (threshold of 20N) making up the second step. Rest periods were provided as necessary. The standard instructions (translated from French to English) that were used to inform subjects of the task requirements were "Descend the stairs maintaining your natural speed. A coloured word could appear on the screens at the bottom of the stairs anytime during approach and descent with the same word on all four screens to facilitate visualization. If the word appears, you are to name the colour of the letters of the word (as for the sitting task) as quickly as possible while maintaining your walking speed. Do you have questions?"

2.4 Dependent Variables

Gait speed was calculated from the mean forward center of mass (CM) velocity for the two footsteps related to Stroop presentation. Only the second initial footstep after initiation (step 1) was analysed for approach due to limits camera lengths of view. The footsteps at transition corresponded to descending the first two steps (1 and 2) of the staircase. The footsteps of steady state descent referred respectively to stepping onto steps three and four. Fluidity of progression corresponded to the number of zero crossings in the anterior-posterior acceleration of the CM as previously used for other gait studies (Atallah et al. (2012) Ibrahim et al. (2010)). Fewer zero crossings indicate more fluid motion. Minimum foot clearance was measured as the minimal distance between the shoe sole and each stair edge (Telonio et al. (2013)) with edge one corresponding to the top platform. Verbal response times to the Stroop task were calculated as the time between the beginning of the recorded voice response and the stimulus presentation. Dual task costs (DTC) were calculated as the difference between response times during descent and an average of the two baseline response times.

2.5 Data analysis

For the spatio-temporal data at transition and steady-state descent, repeated measures three-way (2 Stroop tasks x 2 steps x 2 groups) ANOVAs were applied for each section (2 steps). For gait speed and fluidity during approach, two-way (2 Stroop tasks x 2 groups) ANOVAs were applied as the first step was unavailable (see above). Given the focus on group differences and the use of only 2 levels for the ANOVA factors, no post-hoc testing was performed for this data. A two-way (3 position x 2 groups) ANOVA was used for DTC data where position was approach, transition and steady-state. Group differences for clinical tests were compared using independent T-tests. All significance levels were set to 0.05 and significant p-values were disclosed.

For errors on the Stroop task, a Poisson Regression analysis was performed to estimate the magnitude (plus and minus the 95 % confidence interval) to which the older group differed from the younger group. No differences are represented by an estimate of one.

3. RESULTS

Normal age related differences were found for physical and cognitive abilities (Table 1). There were no group differences for activity levels ($p = 0.795$). The older group only walked significantly slower than the younger adults ($p = 0.005$) for maximal walking speed. Balance self-efficacy was lower for older adults ($p = 0.021$), specifically for the more demanding environments of walking on ramps ($p = 0.033$), transition on an escalator with parcels ($p = 0.047$) and walking on icy sidewalks ($p=0.012$) as would be expected (Powell and Myers, 1995) . Balance Scale scores for the older group ranged from 54 (for one subject) to 56 similar to that observed by Steffen et al. (2002). The significant group difference ($p = 0.014$) for this score was mainly due to the perfect scores for the younger group.

Neuropsychological performances are illustrated in Table 1. Older individuals were slower than younger adults at tasks evaluating visual attention (Variability for CPT, Number ($p = 0.003$) and Letter sequences of TMT-DKEFS, $p < 0.001$ for both) and visual scanning (from TMT-DKEFS, $p < 0.001$). The older individuals' performance were also lower than younger adults in tasks assessing attentional switching ability (Number-Letter Switching of TMT-DKEFS, $p < 0.001$), Inhibition/Switching sub-test of Stroop, $p < 0.001$), inhibition processes (Color-word sub-test of Stroop, $p < 0.001$) and planning (Correct response and Categories completed at the WCST; $p = 0.009$ and $p = 0.006$). These differences between groups represent normal age-related changes in cognitive functions (Di Fabio et al. (2005)). In contrast, both groups did not differ with respect to motor speed (Motor Speed of TMT-DKEFS; $p = 0.224$), verbal working memory (Brown-Peterson Paradigm; $p=0.893$) or perseveration (perseverative errors of WCST; $p = 0.179$).

Summarizing the physical and cognitive testing, the older adult group was representative of a physically fit, healthy aging population with normal cognitive decline.

Although older subjects appeared on average to descend slower, there were no main group effects for speed during approach ($F_{(1,30)} = 1.680$, $p = 0.205$), transition ($F_{(1,30)} = 3.730$, $p = 0.063$), or steady-state descent ($F_{(1,30)} = 2.731$, $p = 0.109$)(Figures 2A to E). For approach (Figure 2A) there was a Stroop effect ($F_{(1,30)} = 15.699$, $p < 0.001$) as both groups quickened their gait speed during approach with a dual task. During transition (Figures 2B and C), there was a main effect for step ($F_{(1,30)} = 106.807$, $p < 0.001$) as well as step by Stroop ($F_{(1,30)} = 5.778$, $p = 0.023$) and step by group ($F_{(1,30)} = 5.77$, $p = 0.023$) interactions. Generally, step 2 of transition was slower as all subjects began true descent and although Stroop may have played a role, there was no 3-way interaction. There were no significant differences for Steady-state descent gait speeds. Thus, both age groups showed similar behavior for gait speed.

Fluidity during approach (Figure 3A) resulted in main group effects ($F_{(1,30)} = 10.413$, $p = 0.003$) but no other significant effects of interactions. Essentially, older adults showed less fluidity during approach. There were no group effects for either transition (Figures 3B and C) or steady-state descent (Figures 3D and E). However, for transition, there were significant Stroop ($F_{(1,30)} = 6.670$, $p = 0.015$) and step ($F_{(1,30)} = 52.150$, $p < 0.001$) effects. The Stroop effect is due to improved fluidity with dual tasking, while the step effect is as noted above for speed, likely due to the decrease in speed for the second transition step. For Steady-state descent, there was a significant step effect ($F_{(1,30)} = 88.763$, $p < 0.001$) as well as a Stroop by step interaction ($F_{(1,30)} =$

12.854, p = 0.001). Fluidity significantly improved again with dual tasking for both groups for the first steady-state footstep (step 3), but not for step 4.

Minimum foot clearance (MFC Figure 4) was analysed for the steps of transition and steady-state descent. During transition (Figures 4A and B), there was a main group effect ($F_{(1,30)} = 10.254$, $p = 0.003$) with higher MFCs for the older adults (Figure 3). There was also a significant step effect ($F_{(3,90)} = 98.866$, $p < 0.001$) as well as a 3-way Stroop by step by group interaction ($F_{(3,90)} = 4.414$, $p < 0.044$). The data specifically showed that the second step was cleared higher by both groups, but only the older subjects increased their MFC from single to dual task for the second step. During Steady-state descent, again there was a group effect ($F_{(1,30)} = 4.227$, $p = 0.049$) and a step by group interaction ($F_{(1,30)} = 7.822$, $p = 0.009$). The differences between groups for the first Steady-state step (step 3) were similar to step 2 at transition, but there was no dual task effect. Both groups had more similar MFCs on step 4.

During data collection, there was no appearance of contact with the stairs. However, upon analysing the data, it was noticed that some subjects passed very close with the sole of the shoe (less than 1 mm on 22.5 % of all trials for the young group and on 10.3 % of all trials for the older group). Closer inspection of the foot velocity data and slow motion video recordings confirmed that for trials with clearance less than 1 mm, the foot appeared to “waver” (decreased velocity) very briefly over the step. Our interpretation of this is that there was perhaps brief contact, possibly to intentionally receive haptic information about the step position under the swinging foot. Such behaviour was observed more for the first transition step (45.5 % of all low clearances for the young and 46.3 % for the older group, while for the other steps this ranged from 8-18 % for the younger group and 2-22% for the older group). Although interesting, this is beyond the scope of the present study and requires future consideration. However, this behaviour does support the MFC results of higher clearances for the older group and lower foot clearances for the first transition step for both groups.

For performance on the cognitive task, 50% (eight) of the older group committed errors compared to only 37.5% (three) of younger subjects (Table 2). The older group also showed a greater range of errors committed, with some subjects producing up to 4 errors. The number of errors for older subjects were greater for each condition as well, but found to be significantly different from the expected value of 1 (or no difference) only for the total combined errors (4.5 times greater; p =0.02; CI 1.3 to 16.1).

There was a main group effect for DTC which was significantly higher for the older adults ($F_{(1,30)} = 23.889$, $p < 0.001$) (Figure 4). There was also a main effect for position on the stair case ($F_{(1,30)} = 29.00$, $p = 0.009$). However, there was no interaction between group and stair position. The position effect was further explored using post-hoc tests showing that Steady-state DTC was significantly lower than approach (p=0.006). It was also observed that younger adults responded to the transition Stroop during the swing to the first step 69.2 % of the time, while the older adults responded the majority of time (66.6 %) after contact on the first step.

4. DISCUSSION

The results showed general age related effects in stepping behaviour and ability to process visual information. With respect to specific dual task effects, the older group showed both greater DTCs and different minimal clearance behavior specifically at transition to stair descent.
In general, both age groups performed similarly across conditions with respect to changes in speed and fluidity during both single and dual task conditions and general DTCs for responding to the Stroop task. Therefore, the older adults maintained the general capacity to descend stairs even with divided visual attention. However, the older adults performed with more caution as evident through the tendency for slower descent and significantly higher minimal foot clearances. The overall higher DTCs by older subjects during descent, suggest a general increase in time needed to process the cognitive task and is supported by their general age related slowing in attention and switching processes (see Table 2). These findings also concur with previous work in our laboratory (Gerin-Lajoie et al., 2006) for obstacle avoidance. Thus, the current data suggests that similar environment specific movement strategies are used across adulthood, but older adults, even when active and healthy, appear to develop more prudent behavior and generally require more time to process information.

In addition to these general age related factors, there were also interesting group differences specific to the point of transition to stair descent. Given previous literature on visual processing and planning for stepping over obstacles (Mohagheghi et al., 2004; Patla and Vickers, 1997) , dual task effects are expected to be less for younger subjects for the transition to descent even though this point still shows executive demands for stair ascent (Miyasike-daSilva and McIlroy, 2012) . This was the case for the younger adults, and, in partial support of our hypotheses, older adults showed increased clearance of the second transition step and waited later on average to respond until after first transition foot contact. Yet, gait fluidity was not decreased. Although subtle, the foot clearance changes suggest that older adults are less “automatic” at this transition point than younger adults and may be more susceptible to visual interference. Thus, although older adults retain a basic capacity to perform dual tasks, there appears to be more attention given to prudent-like behaviour during the transition steps.

The increase in clearance for the second transition step only may be explained by visual control. The simultaneous visual task was projected on monitors at the bottom of the stairs relatively aligned with the line of sight of the staircase. Thus, the first transition step could benefit from peripheral, or possibly direct, vision, while the second step was taken without vision of the foot when older adults were responding to the stimulus. Given that the first two steps are when falls are more frequently seen (Jackson and Cohen, 1995) this period of stair descent would presumably be particularly risky for older persons with affective problems such as fear of falling or with cognitive deficits from different severities.

The present observations appear to concur with (Ojha et al., 2009) that older adults take longer to respond to a simultaneous task during steady state descent (here for descent only). Older adults in the present study had greater DTC and foot clearance than younger adults during steady state descent. However, transition appears to result in more obvious dual task effects and possibly greater demands on visual attention with normal aging.

The key feature of the dual tasking protocol used in the present study is the visual interference it causes with gait. There are many visual stimuli that compete for our attention in daily public and home environments. Given the present results, active, healthy, older adults would appear to continue to give more attention to the staircase during descent, but particularly at transition. We did not specifically measure gaze behavior, but work with younger adults during obstructed walking (Rhea and Rietdyk, 2007), descending a step (Timmis et al., 2009) and stair ascent (Miyasike-daSilva and McIlroy, 2012) suggest that peripheral visual is necessary during the transition phases. Miyasike-daSilva and McIlroy (2012) in particular showed that young adults do not use foveal fixations to specific stair features during transition to ascent, and were more affected by visual interference, thus suggesting the importance of peripheral vision. The reliance on peripheral visual information appears to be of greater importance as we age (Anderson et al., 1998) and therefore may explain why the Stroop task had greater interference for the older adults during descent, particularly at transition.

In relation to peripheral visual control, the use of corrective glasses (ignoring contact lenses that allow the correction to follow the eye) should be considered. In the present study, eleven older adults and seven younger (eyewear information missing for one subject and head pitch data only lost for another) adults wore glasses. For the older group, 10 glasses were multi-focal with 1 uni-focal, while the younger subjects with glasses were all uni-focal. A main effect for group was found showing that the older subjects pitched their head more forward versus younger subjects in general ($F_{(1,10)} = 10.573$, $p = 0.009$), and there was a main Stroop effect ($F_{(1,10)} = 10.254$, $p = 0.009$) and stair position effect ($F_{(1,10)} = 5.484$, $p = 0.041$). However, there was no effect of wearing glasses ($F_{(1,10)} = 0.450$, $p = 0.518$) (Table 3). Thus, the fact that subjects, particularly older subjects, regardless of wearing glasses or not, pitched their head further forward may be a strategy to aid foveal vision or optimize peripheral vision, but does not appear to be because of eyewear obstruction. A more focused study on gaze and eyewear is, however, required.

~~It is also interesting that body fluidity significantly improved for the young group during the dual tasking for both transition and steady state descent, while the older group only improved during steady state descent dual tasking. These improvements in fluidity correspond with Stroop presentation on the screens at the bottom of the staircase and therefore may be related to the need to provide a more stable visual plateau. The fact that older subjects only improved fluidity during Stroop presentation at steady state descent, may be a further indication of the greater attention required by the transition phase for this group.~~

There have been a number of studies of dual tasking during gait for older adults. In addition to focusing on stair descent which is a particularly risky daily activity for this population, the present work also combined careful screening and testing of cognitive and physical abilities of the subjects. This allowed us to assure the level of fitness and health of the two groups and to focus primarily on aging effects and relate the observed dual task behaviour to age specific abilities. Also, the simultaneous visual task used here invoked a situation frequently found in daily navigation where visual stimuli compete with the need to visually attend to the locomotor task. Given the effects in such an active older population, this work also informs rehabilitation specialists with respect to issues crucial for retraining locomotion in older persons that have mobility impairments, cognitive deficits or both. These results may also be the base upon which further study can focus on variables to improve more ecologically based clinical assessment of mobility problems.

The study is, of course, not without limits. Larger cohorts are always desired and gender issues should be considered in the future. As well, while the present cohort of healthy, active subjects allows us to focus on age-specific factors, a more representative group of older adults with wider ranges of physical abilities and aging effects would be interesting to study. Also, Vision was only verified with the Snellen chart and we cannot say without more extensive ophthalmologic testing whether both groups truly had the same corrected vision. More direct measures of visual gaze would also be interesting. Finally, although five steps are probably the minimum to capture steady state descent, we cannot say that planning for the transition to floor gait was not involved, although this was the same for both groups.

5. CONCLUSION

Healthy, active, older adults maintain their capacity to descend stairs even with divided visual attention. However, they descend with more caution and higher dual task costs that can be associated with age related changes in attention ability. Specifically, at the transition to stair descent when fall risk is greater, healthy older adults appear less “automatic” and more susceptible to visual interference than younger adults. Accounting for age related attention demands will go a long way to providing safer, age-friendly environments. The present findings are also important for retraining locomotion in older persons with mobility impairments and cognitive deficits and may also be important to develop more ecologically based clinical assessments of mobility.

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Figure captions:

Figure 1: Photograph of staircase indicating the second (2; dashed line) step for the Approach phase, and first (1; solid lines) and second (2; dashed lines) steps for the Transition and Steady State descent phases. Also shown are the four screens used to display the Stroop task, the relative positions of the two light switches and one of the Optotrak cameras.

Figure 2: Forward velocity (A,B) and fluidity (C,D) during single (A,C) and dual (B,D) tasking for 1st and 2nd steps during approach, transition and steady state descent by younger (open triangles) and older (black triangles) adults. Vertical whiskers indicate one standard deviation. Horizontal bars indicate significant differences between conditions for the younger (top bars) and older (bottom bars) groups. Cross symbols indicate significant differences with single tasking.

Figure 3: Minimum foot clearance during single (A) and dual (B) tasking for 1st and 2nd steps during transition and steady state descent for younger (open triangles) and older (black triangles) adults. Vertical whiskers indicate one standard deviation. Horizontal bars indicate significant differences between conditions for the younger (bottom bars) and older (top bars) groups. Asterisks indicate differences between groups.

Figure 4: Dual Task Costs during approach, transition and steady state descent for younger (open triangles) and older (black triangles) adults. Vertical whiskers indicate one standard deviation. Horizontal bars indicate significant differences between conditions for the younger (bottom bars) and older (top bars) groups. Asterisks indicate group differences.

	Mean ±SD	
	Young adults	Older adults
Physical assessment		
Activities Balance Confidence Scale (/48)	45.63 ± 2.63	*43.06 ± 3.28
Baecke Questionnaire (/15)	8.10 ± 1.16	7.98 ± 1.45
Balance Scale (/56)	56 ± 0.00	*55.56 ± 0.63
Tinetti – walking (/16)	15.94 ± 0.25	16 ± 0.00
Walking speed (m/sec)	1.51 ± 0.13	1.45 ± 0.15
Maximal walking speed (m/sec)	2.34 ± 0.26	**2.07 ± 0.24
Neuropsychological assessment		
Wisconsin Sorting Card Test		
correct responses (/64)	53.25 ± 3.79	**46.31 ± 8.87
categories completed (/6)	4.31 ± 0.79	**3.06± 1.49
Brown Peterson Paradigm		
Total (/36)	28.13 ± 5.62	27.88 ± 4.79
Conners' Continous Performance Test II		
Omissions	1.19 ± 1.87	5.88 ± 10.04
Commissions	15.81 ± 6.48	13.19 ± 8.10
Variability	4.72 ± 1.70	**7.73 ± 3.80
Trail Making Test (sec)		
Visual scanning	14.36 ± 2.77	**21.65 ± 2.97
Number sequencing	25.26 ± 11.07	**36.40 ± 8.89
Letter sequencing	21.09 ± 6.57	**38.48 ± 9.77
Number-letter switching	46.98 ± 14.67	**100.21 ± 24.71
Motor speed	20.09 ± 8.36	23.17 ± 4.41
D-KEFS – Stroop (sec)		
Color	23.66 ± 4.00	**29.17 ± 3.38
Word	18.81 ± 3.11	20.82 ± 3.61
Color-word	38.51 ± 7.62	**63.88 ± 9.46
Inhibition-switching	46.44 ± 10.01	**62.42 ± 12.49

Notes: * $p < 0.05$ ** $p \leq 0.01$

Table 1 Clinical assessment results

	Young adults	Older adults
# of subjects committing errors	3	8
Range of max. # of errors/subject	1-2	1-4
	Estimate (Lower/Upper Confidence Intervals) (%) for Poisson Regression	
Combined group errors:	4.5 (1.26/16.1)*	
Approach	7.0 (0.90/54.66)	
Transition	6.0 (0.77/46.75)	
Steady State descent	2.5 (0.57/11.05)	

Notes: * $p < 0.05$

Table 2 Response errors to Stroop trask

Table 4 : Mean forward head pitch angles (+/- sd) between subjects with and without glasses for each age group across conditions during approach and first transition

		Younger		Older	
		Pitch (deg)	p	Pitch (deg)	p
Approach No Stroop	Glasses	20.99 (8.22)	0.383	31.25 (9.17)	0.913
	No Glasses	17.17 (5.5)		33.2 (13.43)	
Approach Stroop	Glasses	23.65 (7.17)	0.259	36.02 (8.88)	0.913
	No Glasses	19.38 (7.21)		36.19 (14.37)	
Transition No Stroop	Glasses	20.4 (9.52)	0.383	28.49 (7.41)	0.913
	No Glasses	16.44 (6.29)		30.06 (15.52)	
Transition Stroop	Glasses	22.74 (9.76)	0.318	34.14 (9.06)	0.913
	No Glasses	19.7 (6.88)		34.38 (16.08)	

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