Original Article

The Influence of Audio-Visual Cueing (Traffic Light) on Dual Task Walking in Healthy Older Adults and Older Adults with Balance Impairments

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Abstract

***Background*: The walking gait of older adults with balance impairment is affected by dual tasking. Several studies have shown that external cues can stimulate improvement in older adults' performance. There is, however, no current evidence to support the usefulness of external cues, such as audio-visual cueing, in dual task walking in older adults. Thus, the aim of this study was to investigate the influence of an audio-visual cue (simulated traffic light) on dual task walking in healthy older adults and in older adults with balance impairments.**

***Methods*: A two-way repeated measures study was conducted on 14 healthy older adults and 14 older adults with balance impairment, who were recruited from the community in Chiang Rai, Thailand. Their walking performance was assessed using a four-metre walking test at their preferred gait speed and while walking under two further gait conditions, in randomised order: dual task walking and dual task walking with a simulated traffic light. Each participant was tested individually, with the testing taking between 15 and 20 minutes to perform, including two-minute rest periods between walking conditions. Two Kinect cameras recorded the spatio-temporal parameters using MFU gait analysis software. Each participant was tested for each condition twice. The mean parameters for each condition were analysed using a two-way repeated measures analysis of variance (ANOVA) with participant group and gait condition as factors.**

***Result*: There was no significant between-group effect for walking speed, stride length and cadence. There were also no significant effects between gait condition and stride length or cadence. However, the effect between gait condition and walking speed was found to be significant [F(1.557, 40.485) = 4.568, P = 0.024, η_p^2 = 0.149].**

***Conclusion*: An audio-visual cue (simulated traffic light) was found to influence walking speed in both healthy older adults and in older adults with balance impairment. The results suggest that audio-visual cues could be incorporated into healthy lifestyle promotion in older adults with balance impairment.**

Keywords: *older adults, balance impairment, audio-visual cueing, dual task walking, healthy lifestyle promotion*

Introduction

Autonomous interaction with the environment is a requirement for safe ambulation in the community. It is important for older adults to be able to walk safely while performing dual task challenges in a variety of potentially dangerous situations, such as negotiating obstacles or walking across the road. Unfortunately, the ability of older adults to walk safely is compromised when performing a dual task. While walking, some older adults even come to a complete stop when faced with a dual task, which is identified as a potential fall risk (1). This is especially true for older adults with balance impairment, who are more affected than healthy older adults when performing a dual task (2). A previous systematic review also reported that balance impairment is associated with an increased fall risk in older adults (3). This is a result of impairments associated with increasing age in many systems, including the neuro-sensory and musculoskeletal systems. Thus, older adults have compromised physical function and increased risks of comorbidity.

Mafauzy (4) recommended that the promotion of a healthy lifestyle could reduce the incidence of illness and disability in older adults. This is supported by Sherington et al. (5), who reported that regular exercise could prevent falls and improve the quality of life of older adults. Another strategy, suggested by Figueiro et al. (6), supports the use of additional cues in the living environment to improve postural stability and fall prevention. External cues are augmented by sensory integration, which is integral to the control and guidance of movement. Multisensory cues such as audio-visual (AV) cues could therefore potentially enhance the motor control capability of older adults. Due to the decline in sensory processing in older adults, Laurienti et al. (7) suggested that using multiple sensory channels rather than a single sensory channel might be more effective in improving response times in older adults than in young adults. These results are supported by a later study that found that AV cues improved the reaction time in older adults more than in young adults (8).

Since walking requires the ability to interact with the external environment, external cues are needed to control and adjust walking kinematics. Many walking variables, such as walking speed, are important for rehabilitation and predict successful community ambulation. Previous reviews have stated that walking speed is the sixth vital life sign in humans because it is associated with functional ability and, more importantly, it could be used to predict the future health status and functional decline of an individual (9). Other gait variables such as stride length and cadence were also found to be affected by performing a dual task (10). When walking in an outdoor environment, many older adults were found to decrease both their preferred walking speed as well as their walking speed in potentially hazardous situations, such as walking while talking when crossing the street. It is therefore important to improve the physical capabilities of older adults by promoting a healthy lifestyle.

Promoting the use of external cues is important in improving physical function in older adults. A previous study reported that older adults made more kinematic errors while performing a goal directed movement when the visual cues were lost (11). Similarly, Mahoney et al. (8) reported that older adults demonstrated greater reaction time improvements, compared to young adults, when stimulated AV and visual-somatosensory (VS) cues. AV cues were also found to improve the physical functioning of older adults with Parkinson's disease when performing a dual task. Moreover, Mak et al. (12) reported increases in walking speed, stride length and cadence when walking with the addition of AV cues (a simulated traffic light system), thus demonstrating the benefit of AV cues for improving postural and kinematic control.

Many healthy older adults and older adults with balance impairment have exhibited compromised walking performance when performing dual tasks (13). Dual task walking was found to have a greater impact on the older adults with balance impairment than on healthy older adults. In order to improve the quality of life in older adults it is therefore necessary to improve their movement control while dual task walking. A previous study has suggested the need to investigate the clinical efficacy of multisensory interventions on health care and quality of life in older adults (7). The provision of external cues is an interesting alternative intervention. There are, however, no previous studies that have reported the clinical utility of external cues in improving walking performance while performing dual tasks. Thus, the aim of this study was to investigate the influence of an AV cue, such as a traffic light, on dual task walking parameters in healthy older adults and in older adults with balance impairment.

Methods

Participants

A two-way repeated measures study was conducted at The Human Interface and Mobile Device Laboratory, Mae Fah Luang University, Thailand. A total of 80 participants, aged between 60 and 74 years, who were able to walk at least eight metres independently, were recruited from the Nang Lae district, Chiang Rai, Thailand. They were then excluded from the study if they scored less than 14 on the Mini-Mental State Examination: Thai version (MMSE-Thai 2002), if they had a score of more than 23 on the Thai Falls Efficacy Scale-International (Thai FES-I) or if they had a past medical history that compromised their movement control or kinematics, such as stroke, Parkinson's disease, osteoarthritis or vestibular disease. Of the 80 potential participants who were initially screened for inclusion in the study, 41 potential participants did not meet with the inclusion criteria, having low MMSE scores, hearing problems, visual impairment or abnormal movement issues. In addition, there were 11 participants who could not participate in the experiment for personal reasons. Thus, a total of 28 participants met the inclusion criteria, comprising 14 healthy older adults and 14 older adults with balance impairment (Berg Balance Scale less than 45 of 56). The sample size estimation for this study was calculated using G*power 3.0.10 software to calculate a within-subjects ANOVA with repeated measures. The effect size was based on a previous study on the effect of external cues on single and dual task walking speed (14).

A 2 × 3 repeated measures ANOVA with group (healthy older adults versus older adults with balance impairment) and gait condition (normal walking speed versus dual task walking versus dual task walking with simulated with traffic light) factors was used in this study. The study protocol was explained to the participants, and all participants provided written informed consent before taking part in the study. The study protocol was approved by the Mae Fah Luang University Ethics Committee.

Study Design

The participants were tested individually on one occasion under three walking conditions. They were first asked to walk at their normal preferred speed, followed by two further walking tests, the order of which was randomly determined: dual task walking and dual task walking with a simulated traffic light stimulus. Each participant was tested for each condition twice. The participants were given a minimum of two minutes of resting time between testing conditions, or longer if they needed to recover from fatigue. Before they started walking, for each condition, the participants were tested for dyspnoea using the Borg PRE scale and were not allowed to walk if they reported fatigue or increased or difficult breathing. The participants were not permitted to practice the tasks prior to the testing.

For all conditions, the participants walked along an eight-metre pathway with no shoes, in a quiet room. Two Kinect cameras collected data for the middle four metres of each walk (four-metre walk test) to calculate the spatio-temporal parameters. The four-metre walk test has been used in several studies and is considered to be a standard test for gait assessment in older adults (15). Walking speed, stride length and cadence were calculated by MFU gait analysis software. A previous study by Pfister et al. (16) supports the accuracy of Kinect cameras in gait and psychometric assessment.

For all the conditions, the participants were asked to walk at their normal preferred walking speed.

For the first, normal walking condition, the participants were required to walk in a straight line, looking straight ahead with no distractions. For the simple dual task condition, the participants were asked to walk while simultaneously undergoing a verbal place or object naming task (the task was randomly allocated using a lottery system). For the dual task walking condition with additional AV cues, the participants were asked to walk while simultaneously performing the place or object naming task, and while additionally being stimulated with an AV cue in the form of a traffic light. The traffic light was placed in front of the pathway at eye level and closely resembled a real pedestrian traffic light commonly found at pedestrian road crossings in Thailand. The simulated traffic light followed the same sequence of AV cues: a five-second continuous red light accompanied by a rhythmic 1 Hz audible beep, followed by a continuous green light with a 13 Hz audible beep indicating safe conditions to start walking. The participants were instructed to wait and prepare to walk during the red light condition and to start walking when the light turned green.

For the two intervention conditions, the participants were instructed to divide their attention equally between both tasks—the motor task and the cognitive task—while walking. Each participant was tested for each condition twice, with up to 20 min allocated to complete the tests, including the two-minute rest periods. The mean parameters for each condition were then used for statistical analysis.

Statistical Analysis

Between-group baseline characteristics, including age, BMI, number of years in education, MMSE-Thai score and Thai FES-I were compared using independent *t*-tests. The normal distribution of data was tested using a Shapiro–Wilk test. A two-way repeated measures ANOVA was used to analyse the influence of the group and gait condition factors on the spatio-temporal parameters of gait. The level of statistical significance was set at 0.05.

Results

As shown in Table 1, there were no significant differences in baseline characteristics between the two groups. Our null hypothesis for this study was that an AV cue such as a simulated traffic light would have no affect on dual task walking in healthy older adults or in older adults with balance impairment. The results show that there was no significant between-group effect for all variables: walking speed [$F(1, 26) = 0.576$, $P = 0.455$, $\eta_p^2 = 0.022$], stride length [$F(1, 26) = 3.469$, $P = 0.074$, $\eta_p^2 = 0.118$], and cadence [$F(1, 26) = 0.426$, $P = 0.520$, $\eta_p^2 = 0.016$]. In addition, there were no significant effects between gait condition and stride length [$F(1.601, 41.622) = 0.741$, $P = 0.455$, $\eta_p^2 = 0.028$], and gait condition and cadence [$F(1.443, 37.507) = 1.088$, $P = 0.329$, $\eta_p^2 = 0.040$].

A significant effect of gait condition on walking speed was found however [$F(1.557, 40.485) = 4.568$, $P = 0.024$, $\eta_p^2 = 0.149$]. As shown in Table 2, there was increased walking speed both for dual task walking and dual task walking with AV cues for both groups.

Discussion

The purpose of this study was to investigate the influence of an AV cue, such as a traffic light, on dual task walking in older adults with balance impairment. The dual task conditions comprised the participants walking while simultaneously undertaking a verbal place or object naming task. Previous research has shown that this type of cognitive task increases walking performance times in older Thai adults, not significantly different from calculating backwards in threes (17).

Table 1. Baseline characteristics

Demographic Data	OA (*n* = 14)	OBI (*n* = 14)	Mean differences (95%CI)	*t*-statistic (df)	*P*-value[a]
Age (years)	65.13 (4.68)	68.64 (4.75)	2.89 (−0.92, 6.72)	1.56 (26)	0.250
BMI (kg/m²)	24.13 (3.81)	22.89 (5.40)	−0.86 (−4.52, 2.80)	−0.48 (26)	0.108
Number of education years	3.42 (2.95)	2.93 (1.44)	−0.18 (−2.01, 1.63)	−0.21 (26)	0.099
MMSE-Thai score	23.64 (4.43)	22.64 (4.62)	0.16 (−3.38, 3.71)	0.09 (26)	0.835
Thai FES-I	17.47 (1.39)	17.57 (1.34)	−0.21 (−1.89, 1.38)	−0.32 (26)	0.385

OA = Healthy older adults
OBI = Older adults with balance impairment
[a]Independent *t*-test

Table 2. Gait parameters each walking condition

Spatio-temporal parameters	Group	Normal walking speed	Dual task walking	Dual task walking and simulated with traffic light	Effects of gait condition		Effects of group	
					F-statistic (df1, df2)[a]	*P*-value[a]	*F*-statistic (df1, df2)[a]	*P*-value[a]
Speed (m/s)	OA	0.795 (0.110)	0.845 (0.132)	0.874 (0.127)	4.568 (1.557, 40.485)	0.024	0.576 (1, 26)	0.455
	OBI	0.787 (0.172)	0.790 (0.189)	0.815 (0.154)				
Stride length (m)	OA	0.964 (0.091)	1.016 (0.117)	0.937 (0.175)	0.741 (1.601, 41.622)	0.455	3.469 (1, 26)	0.074
	OBI	0.859 (0.150)	0.882 (0.223)	0.910 (0.161)				
Cadence (steps/min)	OA	99.867 (13.861)	100.275 (13.551)	114.498 (32.327)	1.088 (1.443, 37.507)	0.329	0.426 (1, 26)	0.520
	OBI	110.493 (22.917)	113.414 (36.232)	107.885 (30.918)				

[a]Two-way repeated measure ANOVA

A significant effect was found between the gait condition and walking speed, indicating that both dual task walking and dual task walking with an AV cue affected walking speed in both groups. The participants in both groups demonstrated a mean walking speed in the dual task walking condition that was higher than their preferred normal walking speed, indicating that both the healthy older adults and older adults with balance impairment may have given prioritised attention to the postural task (walking) rather than the cognitive task.

Both groups also increased their mean walking speed when dual task walking while stimulated with an AV cue (traffic light). The older adults may have given prioritised attention to the postural task and concentrated more on walking when stimulated with the external cues. The findings of this study are consistent with those of Mak et al. (12), who reported increasing walking speed in older adults with Parkinson's disease when stimulated with AV cues. There could, however, be a different mechanism for brain stimulation in Parkinson's patients by external cues when compared to older adults with balance impairment, as patients with Parkinson's have a reduction in dopamine within the brain, which is known to regulate the mechanism for initiating movement. Thus, the use of external cues could be a compensatory mechanism to stimulate movement by bypassing the basal ganglia (18). The AV cues stimulate brain activity across multiple levels: sub-cortical, early cortical and higher cortical areas. Thus, the superior temporal sulcus (STS) is involved in AV integration (19).

There is some evidence suggesting that multisensory cues improve motor performance in both young and older adults. However, it does not necessarily follow that there should also be cognitive improvements.

The findings from this study suggest that when older adults are given AV cues they selectively paid more attention to the motor task rather compared to the cognitive task (20, 21), and thus the AV cues may improve their gait performance. This was also suggested by Peterson et al. (22), who stated that external cues might help to focus attention on an individual's gait. However, this experiment was conducted as a simulation of a street crossing. Thus, the AV cue was a meaningful stimulus, which could be associated with directing attention to walking faster to cross the street within a finite period of time to avoid being run over. This is supported by Thomas et al. (23), who demonstrated that meaningful sounds can activate the visual sensitivity of the human gait. Importantly, the mean increased walking speed in both dual task walking and simulated walking with a traffic light did not reach the suggested suitable speed for crossing the street. According to Langlois et al. (24), the suitable speed for walking safely across a street is 1.2 m/sec.

Both groups demonstrated an increased walking speed as a result of AV cues (traffic light) during dual task walking. However, the change in mean walking speed for the four-metre gait speed test did not reach the minimum meaningful clinical change of more than 0.108 m/s, as suggested by Goldberg et al. (15).

There were several limitations to this study. First, the consistency of the responses to the cognitive task in this study was not recorded; for example, the number and rate of correct answers (words) throughout the walk could have been noted. This could have provided insight on how the participants switched their attention between cognitive and motor tasks. Second, the AV signals were associated with crossing a street safely, and the participants were socially conditioned by these signals to walk more quickly. It would be interesting to use other AV cues in other social contexts, for example, different types of music with associated rhythms, such as rock music with an enhanced beat. These questions could form the basis for future studies.

Conclusion

These findings demonstrate that walking speed in both healthy older adults and older adults with balance impairment was influenced by an AV cue (simulated traffic light). The results shed light on the importance of rehabilitation programmes with AV cues to improve dual task walking performance in healthy older adults and older adults with balance impairment.

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Conflict of Interest

None

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Authors' Contribution

Conception and design: KK
Analysis and interpretation of the data: KK, SC
Drafting of the article: KK, PK
Obtaining funding: KK
Administrative, technical, or logistic support: SU, WR
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