Universiteit Leiden

Psychologie
Faculteit der Sociale Wetenschappen

The effect of attentional capacity on movement and metaphoric movement instructions in older adults.

Marlou Gosman

Master Thesis: Clinical Neuropsychology
Faculty of Behavioural and Social Sciences – Leiden University

Student number: s1018884
Supervisor: Rebecca Schaefer
Second examiner: Esther Habers

Index

Abstract

Background Degeneration of attentional resources in older adults increases the risk of falls and gait variability. To prevent these risks, different techniques are being used to teach motor skills to older adults. One major theme in teaching motor skills is the difference between implicit and explicit learning, with the use of metaphoric and explicit instructions. In our study, we aimed to determine the relationship between attentional resources and the use of metaphoric and explicit instructions on walking and walking with a dual task.

Methods Sixteen healthy older adults received different instructions (metaphoric and explicit) on a walking task, as a single task (ST) or with a dual task (DT). For the dual task the Letter Fluency Task was used. For attentional capacity, two attentional tasks were performed: the 'cijfer doorstreep taak' (digit crossing task) and the digit span. Step height was used as the walking parameter of interest, corrected for normal step height in the single task condition and taking the difference between single and dual task step height to assess the dual task cost for both instruction types.

Results While receiving explicit instructions, step height in the ST condition was not significantly related to attention capacity, nor were the costs of performing a dual task. However, while walking to metaphoric instructions, higher attention capacity was significantly related to lower step height during the ST condition, $r = 0.665$, $p = 0.005$, but also to a smaller dual task cost, $r = -0.768$, $p = 0.001$.

Conclusion The results suggest that, contrary to our expectations, attentional resources are involved in carrying out the metaphoric instruction, specifically to sustain the instruction over time. This implies that it is beneficial to take the attention capacities in older adults into account when providing metaphoric movement instruction, as people with reduced attention may not benefit, but rather need explicit pointers. But, further research with more participants is needed to investigate the use of metaphoric instructions on objective gait measures and DT.

1. Introduction

As people age, more variability is seen in their cognitive capacity as well as in gait, which each can cause difficulties in their daily life. The (inter-individual) variability in people's cognitive capacity is associated with changes in the neural basis of cognition. The variability in gait, however, is also related to processing of information and attentional functions that are necessary to maintain gait safety and balance (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000). A recent study has indicated that increased levels of attentional function are related to better posture and gait (Volkers & Scherder, 2014). However, studies have also shown that cognitive capacities like attentional resources decline with age (Braver & Barch, 2002). In the United States 13% of older adults (age >65) are diagnosed with geriatric syndromes. These older adults have an increased risk of falling which can be related to imbalance, confusion and unsteady gait (Rubenstein, 2006). When attentional resources decline, the ability of older people to perform concurrent (dual) tasks gets more difficult , which increases the risk of falls (Verhaeghen & Cerella, 2002). Dual task costs are generally measured as a difference score of the dual and single task conditions (Lord & Rochester, 2007). Summarized, cognitive decline can have a destabilizing effect on gait and can cause trouble in the daily life of older adults (Huxhold, Li, Schmiedek & Lindenberger, 2006).

To prevent degradation of gait, there has been a lot of research into different techniques of teaching motor skills to older adults. One major theme in these studies is the difference between implicit and explicit learning, with the use of metaphoric and explicit instructions (Wulf & Shea, 2002). Implicit learning refers to achievement of a motor skill without the concurrent explicit knowledge of that skill. Implicit learning relies more on implicit memory. Implicit memory is defined as an unconscious memory influence of previously encountered information (Maxwell, Masters & Eves, 2000). Correspondingly, imagery techniques and metaphorical instructions can be used for implicit learning and uses implicit memory (Liao & Masters, 2001). An example of an metaphoric instruction would be 'move your leg as if you're playing football'. Explicit learning is a more traditional method and uses instructions which draws the detailed steps that are necessary for skilled movement production (Caljouw, Veldkamp, & Lamoth, 2016). An example of an explicit learning instruction would be 'try walking on your toes and lean backwards'.

Studies using sequence-learning tasks (Frensch, Wenke & Rünger, 1999; Jiménez & Méndez, 1999) suggest that implicit processes demand less attention capacity, because of the use of implicit memory. This form of memory often remains stable with age, or shows only slight age-related changes, whereas explicit memory declines when people age. Explicit processes are more attentionally demanding, because conscious attentional involvement is needed (Verhaeghen & Cerella, 2002; Ballesteros, 2015). Further research has shown that older adults receive more benefit from implicit learning strategies (Liao & Masters, 2001).

Similarly, research has been reported in which people with amnesia could not use explicit memory efficiently, but rely mainly on implicit memory for task-performance (Wilson, Baddeley, Evans, & Shiel, 1994). Importantly, implicit memory does not need a conscious recollection of the prior knowledge that the memory is based on. Explicit memory requires such recollection and thereby is more cognitively demanding.

Although there is a lot of information about older adults and their attention functions, gait posture and learning capacity (implicit or explicit), we know little about the exact workings and interactions of these mechanisms. The focus of this paper is to better understand the relation between attentional functions, gait and how to instruct older adults with the use of explicit instructions and metaphoric instructions during exercising and performing dual-tasks.

Attention and gait

Research has shown us that attentional demands are associated with postural control in older adults. There are many different types of attentional functions (Hall, Echt, Wolf & Rogers, 2011). Out of these different types of attentional functions, we here describe attention as the capacity to focus on one specific task for a continuous amount of time without being distracted (sustained attention).

Lajoie, Teasdale, Bard & Fleury (1996) investigated the attentional capacity associated with walking with- and without dual task. Eight older adults and eight young adults participated in this research. While walking on an eight-meter-long pathway the participants carried out a secondary task. This task was an auditory reaction time task. Although this task is considered a relative simple motor behavior, the elderly and young persons both responded with greater delays on the auditory task while walking. This suggested that walking is not fully automatic behavior.

Parameters used to assess gait were walking cycle, walking duration, cadence and walking speed. They were measured using an instrumented walkway and kinematic analysis was performed. Older adults adopted a slower walking speed and cadence cycle in both conditions in comparison with the younger adults. Despite the small groups the authors suggested that standing and walking require greater cognitive and attentional resources in older adults than in younger participants.

A study by Holtzer, Wang and Verghese (2012) assessed the relationship between cognitive functions and gait in sixty non-demented older adults. The following tests for cognitive functions were incorporated into the neuropsychological battery; the digit span, symbol search, block design, Boston naming test, letter fluency, category fluency and the trail making test. Quantitative gait variables were collected using a 12-ft instrumented walkway. For the single task condition, people were asked to walk at normal speed. For the dual-task condition, they were asked to pay equal attention to talking while walking on the walkway. The findings suggested a central role of attention in predicting changes in gait performance in both single and dual-task conditions. Dual-task costs were observed in velocity, cadence and stride length implicating attentional resources as a key determinant of changes in these gait parameters. Results also showed that higher executive attention scores predicted faster gait velocity and lower variability in stride length in the dual task condition.

Taken together, it appears that there is a relationship between attentional capacity and walking with- and without dual task in older adults. Having fewer cognitive resources is related to walking more slowly, a slower cadence cycle and more gait instability. This suggests that it is important that during walking, elderly people do not overload their cognitive resources because it can increase the risk of falling. However, it remains an open question whether different types of walking instructions can be used for older adults, which may be easier to understand and do not overload cognitive recourses. This will be explored in the following paragraphs.

Implicit & explicit instructions

Previous research suggest that motor skills are initially learnt explicitly through cognitive processing (Maxwell et al., 2001). As learning progresses, for example by performing skills more often, by getting feedback, and by receiving instructions, the skills become automatic or implicit. The learning stages are recognized by conscious processing of task-relevant information resulting in intuitive judgments about how best to perform the task (Maxwell, Masters & Eves, 2000). This is a different view from earlier research by Masters (1996). According to his research, implicit performance improves without explicit knowledge. The difference between implicit and explicit learning is the amount of explicit knowledge about movement production that is stored by the learner.

Kleynen et al. (2013) investigated the use of analogy learning in stroke patients with no severe cognitive problems (MMSE > 26). Their aim was to assess the efficacy of analogies to improve the walking performance in stroke survivors. Analogy learning integrates the more complex (explicit) instructions into a simple biomechanical metaphor (implicit) that can be executed by the participant. This metaphoric instruction can be used by the learner to apply it to their walking. They tested three men aged 76, 87 and 70 years who were 6, 1 and 3 years post-stroke. Participants were asked to use the analogy during walking and try to integrate it in their performance, they practiced this with a therapist in ten sessions. To assess efficacy, walking performance was measured using the 10-meter Walking Test (10MWT). The gait parameter that is used in this test is walking speed. Two of the participants had a significant improvement (above 0.06 m/s) on walking speed on the 10MWT with the use of metaphors compared to the baseline. Because of an unforeseen occasion unrelated to the intervention, participant 3 received extra medication, which negatively affected his post-training 10MWT performance. The authors suggested that the analogy must have a meaning to the individual, otherwise the metaphoric instruction is costlier in terms of cognitive demands. The participants first need to imagine and understand the instruction to be able to integrate it into their walking.

These studies suggest that metaphorical instructions, with the use of implicit learning strategies, are easier to understand and can help to improve walking speed performances. But still, little is known about how this relates to cognitive resources like attention and how this is impacted by a dual task.

Dual task walking

Walking without a concurrent task generally takes place automatically with little conscious control and becomes an automatic movement. The ability to perform automatic movements is an essential aspect of movement control; this increases our functionality because it allows us to do two things at the same time. Cortical input and afferent feedback act to initiate and to adjust gait to anticipate to the environment or when tasks become more complex. This reflects a higher level of control and attention (Lord & Rochester, 2007). Huxhold (2006) carried out research into the dual-task paradigm with cognitive functions and postural control. He tested 19 older adults (mean age = 69) and 20 young adults (mean age = 24). His research presumed that cognitive fuctions and postural control (like walking) compete for limited attentional capacity. Thus, when a person needs to keep walking while performing a concurrent cognitive task, attention is divided between sensorimotor and cognitive tasks. He found that the sharing of attentional resources reduces the amount of attention available for walking and hinder postural control in younger and older adults. Furthermore, he found that older adults had more trouble with tasks that were less relevant to them. The finding that sharing of attentional capacity hinders movement execution is in line with earlier research (Masters, 1996) based on a theory of reinvestment. This research indicated that the less explicit knowledge the performer has, the less likely it is that performance will suffer from interference from conscious processing under stress.

These studies demonstrate a relationship between attention capacity, gait stability and walking. People need a specific amount of attention capacity for gait stability and posture control during walking. When people think more consciously about their walking movement, the more they are at risk for gait instability because cognitive functions get overloaded.

Gait, posture and movement

The term 'functional gait' is used to define a flexible gait, capable of anticipating to environmental demands and unforeseen tasks. An example is walking under complex task and environmental conditions (Yogev et al., 2005).

Agner, Bernet, Brulhart, Radlinger & Rogan (2015) investigated spatial- and temporal parameters for gait speed, cadence and stride length variability in 16 elderly and in 16 young adults. The authors used the following conditions: single task (ST) with only walking, and a dual task (DT) where participants were asked to do a counting task while walking. They compared the two groups to demonstrate the impact of ST and DT on gait parameters. These parameters were gait speed (m/s), cadence (steps/min) and stride length variability, measured with the inertia sensor RehaWatch. The participants completed four different measurements during normal walking and fast walking during ST and DT over a walking distance of 20 m. During the dual-task condition, participants were asked to walk and count backwards in steps of seven, five or three depending on their cognitive ability. In both conditions gait speed, cadence and gait variability were significantly reduced in the elderly compared to the young group.

Summarized, it seems that the older you get, the less automatic walking becomes. For elderly people walking seems to require more cognitive resources such as attentional functions. This implies that when teaching motor skills, instructions become more important as people age. The instructions need to be easy to understand so they do not overload cognitive functions. Explicit and implicit learning strategies are commonly used but little is known about how they relate to attentional capacity. It would be interesting to see how different types of (explicit and metaphoric) instructions relate to attentional capacity and movement execution in elderly people.

Goal of current study

The aim of this study is to evaluate (a) the effect of attention capacity in older adults when receiving metaphoric and explicit instructions during walking exercises on an instructed gait parameter, in this case step height, and (b) how attentional resource allocation contributes to step height in the context of a dual task (measured in dual task cost, so compared to a single task), again with the use of metaphoric and explicit instructions. The following neuropsychological tests will be used for attention capacity; the Digit Span and the Cijfer doorstreep taak *(Digit Crossing Test)*. These tests will be further explained in the methods section. Based on the findings discussed above, we expect attentional functioning is crucial to carrying out explicit instructions but not metaphoric instructions, and that participants with low attention capacity are less impeded during the metaphoric instructions during the single and dual task than with the explicit instructions, whereas for the explicit instruction we expect attentional functions to affect step height. Thus, the first hypothesis is that (1) higher attention capacity is expected to be related to higher step height in the single task condition for the explicit instruction, and we expect no relation between attention capacity and step height for the metaphoric instruction.

Furthermore, we expect that lower attention capacity is related to a greater dual task cost during explicit instructions, in the form of a greater difference in step height between single and dual task (i.e. dual task cost), for only explicit instructions. With regards to the metaphoric instructions we expect less dual task costs on step height. Thus, the second hypothesis is that (2) in the trials with explicit instructions, we expect lower attention capacity to be related to a greater dual task cost. During the metaphoric instructions, we expect no relation between attention capacity and dual task cost. Therefore, we expect that attention capacity is negatively bidirectionally related to dual task cost during explicit instructions, while during metaphoric instruction, attention capacity is not related to dual task cost.

2. Methods

Design

This study used a within-subjects design. Each participant received three different instructions to perform an exercise in relation to walking (no instructions, explicit instructions and metaphoric metaphorical instructions), either with or without a dual task, yielding six experimental conditions (3 instructions x 2 tasks).

Consent

The Scientific and Ethical Review Board of the Faculty of Behavior and Movement Sciences, VU University Amsterdam, has approved the study under protocol number VCWE-S-16-00152.

Participants

We tested 21 healthy older adults between the age of 55-70 years, however during the experimental trials, for unknown reasons, not all data was recorded. The result of this was that for five participants, the data were not included. So, the following report is only about the 16 participants with complete data sets. As such, the sample consisted of 16 participants, 7 men and 9 women (mean age =59.3, sd = 3.5), for more demographic characteristics see Table 1. They were recruited using recruitment materials like flyers and social network. After recruitment, an information letter with informed consent was sent to the participants. Once written consent was received, participants were tested for inclusion and exclusion criteria, namely a history of neurological, vascular or psychiatric disorders. Also, people who took medication that could influence their cognitive and motor capacities were excluded from the study.

Table 1.

Demographic characteristics (N= 16)

Participants	Men, (n=7)	Women, (n= 9)
Age (mean) years	58.9	59.9
Right handed, N (%)	6 (86%)	8 (89%)
Sports activity per week		
2-3 times per week	2 (29%)	6 (67%)
never	3 (42%)	1 (11%)
other	2 (29%)	2 (22%)
Education		
University	6 (86%)	3 (33%)
HBO	0 (0%)	3 (33%)
MBO	1 (14%)	2 (22%)
LBO	0 (0%)	1 (11%)

Materials cognitive functions & attention

To get more insight in the cognitive functions and attentional capacity of the participants, neuropsychological tests were administered. Cognitive impairment was determined by the Mini Mental Stage Examination (MMSE), a test to measure generally cognitive functioning. The MMSE centers on word recall, attention, calculation visuospatial ability, language capacities and orientation in time and place (Volkers & Scherder, 2014). The minimal score for this test is 0 and the maximum score is 30 (Folstein, Folstein, & McHugh, 1975).

Besides the MMSE, four other neuropsychological tests were administered to assess cognitive functioning. These were the Digit Span test, Trial Making Test A & B, DKEFS, and 'Cijfer Doorstreep Taak' *(CDT, Digit Crossing Test)* (Callens, Tops & Brysbaert, 2012; Sánchez-Cubillo et al., 2009; Swanson & Beebe-Frankenberger, 2004). Also, the Movement-Specific Reinvestment Scale and Vividness of Movement Imagery Questionnaire-2 questioners were used (Ling, Maxwell, Masters, McManus,

& Polman, 2015; Williams, Pearce, Loporto, Morris & Holmes 2012), assessing movement metacognition and movement imagery abilities, respectively. For the dual task during walking, the Letter Fluency test was used (Troyer, 2000). For the current research question, only measures from the Digit Span and CDT are used to assess attention capacity, and the TMT and DKEFS and movement questionnaires will not be discussed further.

Digit Span

The Digit Span is a subtest from the Wechsler Memory Scale-Revised and was used to measure attention capacity, namely sustained attention. In the Digit Span, increasingly long sequences of random numbers are vocally presented at a rate of one digit per second. The participants must replicate the sequence in the same and reverse order directly after the vocal representation. This test finishes when a participant cannot recall at least two series of the same length or repeats two eight-digit sequences correctly. For this study, we only used the 'Digit Span Forward' (DSF). The minimal score for this condition is 0 and the best score is 21 (Volkers & Scherder 2014; Ganzach, 2016). Cronbach's alpha = 0.84 (Swanson & Beebe-Frankenberger, 2004).

Cijfer Doorstreep Taak (Digit Crossing Test)

The 'Cijfer Doorstreep Taak' (CDT) was used to measure the participants' speed and accuracy of processing in a task of selective attention and concentration. In the CDT, the participants receive a form which presents 960 digits from 0 to 9 in 16 columns. Participants have three minutes to underscore as many fours and to cross out as many threes and sevens as possible, working in columns. Scores for working pace are created from the total numbers of items processed. A concentration score is constructed from the total mistakes proportional to the total edited items, which will be used during this study. This means that a low score on de CDT (or proportion of errors) is related to a better attention and a high score to a decreased attention capacity. The test retest reliability scores vary between 0.79 and 0.95 (Callens, Tops & Brysbaert, 2012).

Dual task: Letter fluency test

The letter fluency test is used as a dual task and is commonly used to evaluate the linguistic and cognitive abilities. In the letter fluency test, preselected letters are presented to the participant systematically, one by one (Swanson & Beebe-Frankenberger, 2004). For the first trial the letters D, A, T were presented. The second trial the letters K, O, M and the third trial the letters P, Q, R. The participants normally have one minute to provide as many words possible beginning with each phoneme or syllable (Kim, Lee & Yoon, 2015), although in the current setting there was no time limit other than the time to complete the walking task. The Letter Fluency task has a Cronbach's alpha = 0.90 (Troyer, 2000). During this study participants performed the letter fluency task while walking with different instructions. This test is mainly used to investigate whether the dual task influences walking speed. The way we used this test in this situation, it is unreliable for interpreting cognitive abilities.

Materials physical performance

For the physical performance participants were asked to walk on an interactive walkway. Body movements were measured with 4 spatially and temporally integrated Microsoft Kinect v2 cameras. The kinects measured body movements along anterior-posterior and medial- lateral axes. Extracted parameters for body movement were stride length, cadence, and walking speed. These data were centered on a foot being in- and out of contact with the floor measured by the Kinect v2 cameras from respectively the maxima and minima of the anterior-posterior time sequences of the ankles relative to that of the spine base. The variances between the stride length, cadence, and walking speed were obtained by the 4 kinects and further analyzed with Matlab (version 2012b, Natick, MA). In this study, we only consider step height as this relates directly to the given instruction.

The multi-Kinect v2 measurement was validated through an evaluation with a current motion-registration system by defining between-systems agreement for body points time sequences, spatiotemporal gait parameters and the time to walk 10 meters. Between-systems arrangement for the body points' time sequences was measured with the interclass correlation coefficient (ICC). The between-systems procedure was similarly determined for the gait parameters' walking speed, cadence, step length, stride length, step width, step time, stride time, all achieved for the intermediate 6 meters and the time to walk 10 meters. For comfortable and maximum walking speeds, the between-systems procedure for the time to walk 10 meters and all gait parameters excluding step width was high (ICC 0.888). This result was with minor biases and little limits of agreement (Geerse, Coolen, & Roerdink, 2015).

In the current study, step height was calculated as the median height of the foot while the other foot was on the floor, first averaged over three trials per condition for each foot and then averaged over the two feet.

Implicit and explicit instructions

The choices for metaphoric and explicit instructions were based on interviews with six physiotherapists we completed beforehand. We asked them about the most common complaints in older adults, the use of different instructions, which they used most in practical settings and how this may relate to dual tasks. The interviews revealed that different types (metaphoric and explicit) instructions are being used but the physiotherapists are ambiguous about how and why they work. The instructions in this study were chosen as examples of different ways to instruct older adults how to move. The instructions are displayed in Table 2. Furthermore, the physiotherapists told us that especially older adults have more trouble with walking exercises during a dual task.

Table 2.

Walking instructions per condition

Conditions	Instructions for single and dual task.
Baseline	'Walk normally'
Explicit instr.	'Walk while lifting your knee high and stretch your leg'
Metaphoric instr.	'Walk like you're stepping over a high, wide threshold'

Procedure

The experiment took place in one session lasting approximately one hour. At the beginning of the experiment participants were asked to sign an informed consent. After the consent the procedure of the experiment was explained. Then, participants underwent the neuropsychological tests, administered in a random order, taking about 30 minutes. In the second part the participants were asked to carry out the trials with physical activity (walking). For this, participants were informed that they would be performing three trials in each of six different versions of a walking exercise, and asked to follow various instructions. The six conditions consisted of 1) no instructions, 2) no instructions with the dual task, 3) metaphoric instructions, 4) metaphoric instructions with the dual task, 5) explicit instructions, and 6) explicit instructions with the dual task.

Participants participated in all six conditions, always starting with normal walking, and performing all dual-task conditions after all the single task conditions. This created two possible orders which were counterbalanced, one in which normal walking was followed by explicit instructions, and then followed by metaphoric instructions, and another in which normal walking was followed by metaphoric instruction, followed by explicit instructions. This order was kept the same for single and dual task conditions. As a dual task, the Letter Fluency Task is used, with a letter given for every walking trial. Each condition included three repeated trials per condition of 10 meters of walking. The participants were asked to perform in their best possible way.

The debriefing consisted of questions about how the participants experienced the different conditions.

Analyses

Because this is a relatively new study topic with limited previous research, a 3x2 repeated measure ANOVA was conducted on uncorrected data to acquire insight in the experimental manipulations. This was used to analyze and calculate main effects of the instructions and task effects for step height. Beforehand, the assumptions of normal distributions, equal variance and absence of outliers were checked for both corrected and uncorrected data. The assumption of normality was verified with the *Kolmorov-Smirnov* test and the *Shapiro-Wilk* test looking at skewness and kurtosis of the distribution. The assumption of homogeneity of variance was tested with the *Levene's F* test for equality of variances. To examine the first hypothesis, step height for both explicit and metaphorical instructions without a dual task was corrected for normal step height using a difference score (i.e. normal walking step height subtracted from instructed walking step height). To test the first hypothesis, namely the effect of attention capacity on single task and walking with instructions, the CDT and digit span were correlated with corrected step height for each instruction condition. The second hypothesis was tested by calculating the dual task cost by taking the difference scores of single and dual task for step height on the explicit and metaphoric instructions, and correlating these differences to the same measures of attention as before. Depending on the distribution of the data, a Pearson correlation was used (if the data is normally distributed and contains no outliers, assuming a linear relationship), or alternatively a Spearman correlation, should the data be non-normally distributed.

3. Results

Analyses of homogeneity were performed to verify the assumptions of normal distributions, equal variance and absence of outliers. The *Kolmorov-Smirnov* test, the *Shapiro Wilk test* and the *Levene's F test* were performed for the single task (ST) and dual task (DT) conditions with the different instructions on step height (uncorrected data). It showed that all data was normally distributed except the baseline for step height on a DT condition. The baseline for step height on DT condition showed significant results for the *Kolmogorov-Smirnov* $p < 0.001$ and the *Shapiro Wilk* $p = 0.002$. This means the assumptions for normality were not met.

Nevertheless, a repeated measures ANOVA was conducted to test the within-subjects effects of different types of instruction (baseline condition, explicit- and metaphoric instructions), and dual-tasking (single-task versus dual-task) on step height. Results are presented in Figure 1. This figure suggests that despite the counterbalancing of the instructions, there still might be an order effect because participants are making higher steps in all the DT conditions. There was a significant main effect of instruction on step height, $F\ (2, 23.29) = 0.00, p < 0.05$, a significant main effect of task on step height $F\ (1, 7.10) = 0.02, p < 0.05$ and no significant interaction effect (instruction vs task) $F\ (2, 0.81) = 0.47, p > 0.05$. Post hoc comparison revealed a significant effect of metaphoric and explicit instructions compared to the baseline condition. Explicit instructions compared with the metaphoric instructions showed no significant effect.

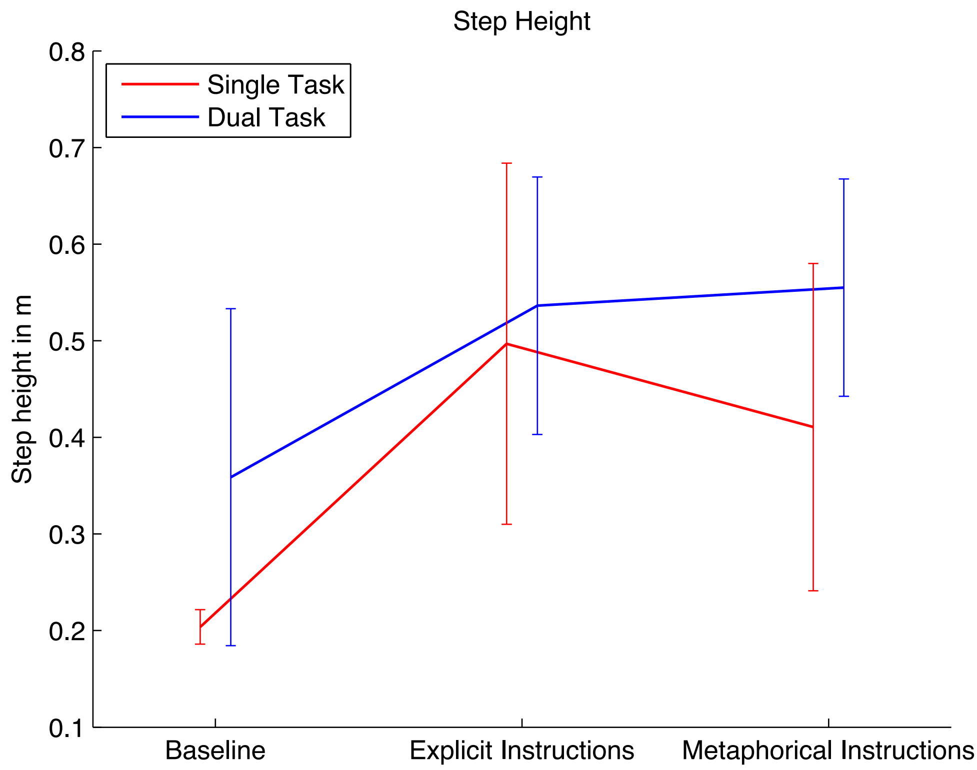

Figure 1. Step-height for the different instructions and difference between single task (ST) and dual task (DT). Error bars indicate 1 sd.

To test the hypotheses, again, the assumptions for homogeneity were checked for the (corrected) data for the ST and DT with the different instructions for step height. The *Kolmorov-Smirnov* test, and the *Shapiro Wilk test* were performed. All corrected measures met the assumptions of homogeneity, allowing a Pearson's correlation to be used.

To test the first hypothesis, the CDT and digit span were correlated with a Pearson's correlation for step height and for each instruction condition. Results are presented in Table 3. These results show a significant relationship between attention capacity (CDT) and step height during the metaphoric instruction and the ST, but not for the explicit instructions. The DSF is not related to step height in either the metaphoric and explicit instructions. This suggests that lower attentional functioning (indexed by a higher proportion of errors on the CDT) is related to higher steps on the metaphoric instruction, see Figure 2. As the correlation is bivariate, this also implies that a higher attentional functioning is related to lower step height on the implicit instruction, which is an unexpected finding.

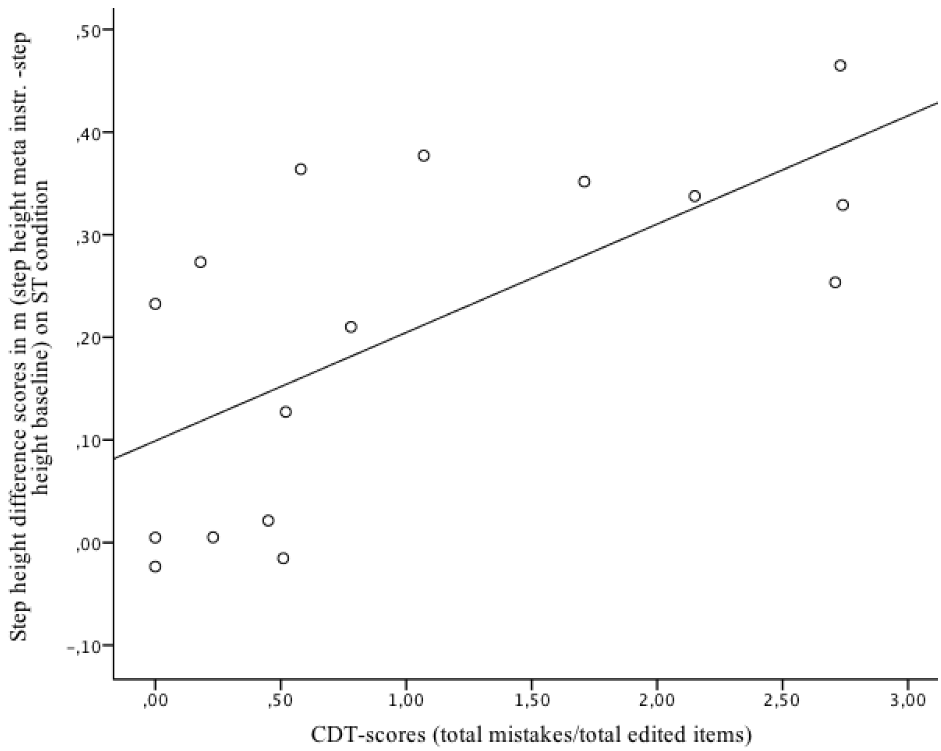

Figure 2. Step height for the dual task cost and the different metaphoric instructions on ST *(N = 16)*.

Table 3.

Pearson correlations between attention capacity (CDT & DSF) and Step height (StepH) on ST condition (N = 16). Significant correlations (p<0.05) are denoted in bold print.

Corrected ST instr.	CDT		DSF	
	r	p	r	p
StepH, ST, expl.	- 0.273	0.306	-0.283	0.288
StepH, ST, meta.	**0.665**	**0.005**	0.086	0.751

To examine the second hypothesis, the CDT and digit span were correlated using a Pearson correlation between step height and the dual task cost for each instruction condition, results are presented in Table 4. These results showed a significant relationship between attention capacity (CDT) and the DT during metaphoric instructions, but not for the explicit instructions. This means that, again, attention capacity (CDT) does not influence step height during explicit instruction. Also, again, the DSF is not related to step height in either condition. This means that a lower attention capacity is related to a bigger effect of the dual task, see Figure 3. This suggests that attention is needed to sustain the metaphor while moving, which is not the case for explicit instructions.

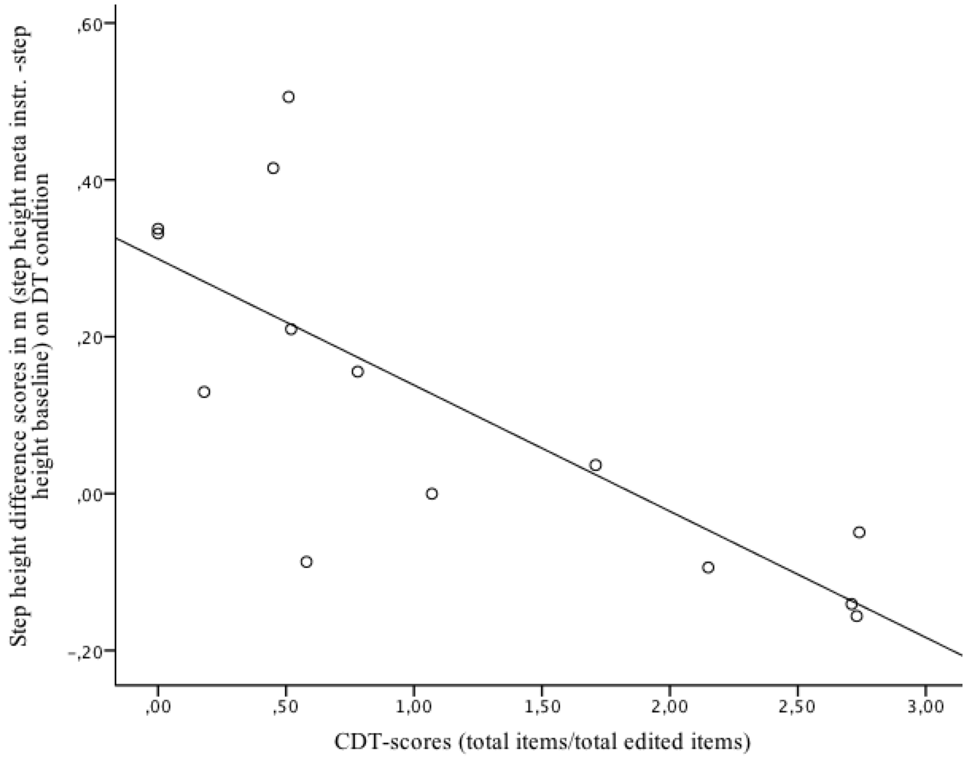

Figure 3. Step height for the dual task cost and the different implicit metaphoric instructions on DT *(N = 16)*.

Table 4.

Pearson correlation between attention capacity (CDT & DSF) and Step height (StepH) and dual task cost (DT) (N = 16). Significant correlations (p<0.05) are denoted in bold print.

Corrected DT instr.	CDT		DSF	
	r	p	r	p
StepH, DT, expl.	0.142	0.600	0.207	0.441
StepH, DT, meta.	**-0.768**	**0.001**	-0.124	0.673

3. Discussion

The current study was performed to see (a) if there was an effect of attention capacity on step height in older adults when using metaphoric and explicit instructions during walking exercises and (b) how attention capacity is related to dual task cost in step height with the use of metaphoric and explicit instructions. It was hypothesized that (1) attention capacity was bidirectionally related to a step height in the ST condition for the explicit instruction and we expected no relation between attention capacity and step height for the metaphoric instruction. Furthermore, (2) we expected that when participants have a lower attention capacity, they would have a larger dual task cost during explicit instructions. On the dual task with the metaphoric instructions we expected no relationship between attention capacity and dual task cost. The hypotheses mentioned above are based on literature stating that older adults benefit more from implicit learning strategies (Wilson, Baddeley, Evans & Shiel, 1994; Verhaeghen & Cerella, 2002; Ballesteros, 2015). Correspondingly, the literature suggests metaphorical instructions are easier to understand which can lead to bigger movement execution (Masters, 1996; Kleynen et al., 2013).

However, in this study, the results showed a significant bidirectional relation between attention capacity and movement execution on dual task cost for only metaphoric instructions in either ST or DT condition. These results suggest that attention function had a bigger impact on the metaphoric instruction than the explicit instruction. For the ST condition a better attention capacity was related to lower step height on the metaphoric instruction. For the DT condition a lower attention capacity is related to a higher dual task cost, which means a bigger difference in step height related to the dual task during the metaphoric movement instruction. This suggests that participants were more affected by the DT on the metaphoric instruction and that attention is needed to sustain the metaphor while moving, which is not the case for explicit instructions. Furthermore, it seems that older adults generally make higher steps on a from the ST to DT condition. Both these effects were unexpected and the ST effect seems especially counterintuitive.

Kleynen et al. (2013) investigated the use of analogy (metaphorical) implicit learning in stroke patients with little cognitive impairment. They found that two of the three participants had significant movement improvement on walking speed which suggests that implicit learning improves movement execution. However, they did not examine how this relates to explicit learning instructions or a baseline; therefore, it is difficult to say if implicit learning is easier to understand. Also, they did not look at the relationship between cognitive skills. Our study looked at the difference between a baseline, metaphoric and explicit instructions and how this relates to cognitive capacity (attention) and step height. The cognitive load in this research was much higher because the instructions were unusual. Participants easily could get confused with the different types of instruction because the trials where given one after the other and this could have influenced our results. Our results correspond with earlier research (Masters, 1996) based on a theory of reinvestment that the less explicit knowledge the performer has, the less likely it is that performance will suffer from interference from conscious processing. Furthermore, we tested healthy older adults without cognitive problems and the metaphoric instructions meant nothing specific to the participants. Most of the participants were confused by the metaphoric instructions and asked for clarification. The study of Kleynen et al. (2013) suggested that instructions needed to be meaningful for the learner. In the current study this was not the case (this means that the metaphoric instructions were not meaningful), which may have affected the results because the participants had to think more about the metaphoric instructions. Because participants found the metaphoric instructions more difficult, this corresponds to the results in our study, suggesting that attention capacity is needed to sustain the metaphoric instruction.

Liao & Masters (2001) suggested that imagery techniques can be used for implicit learning. In our study, participants needed to use imagery skills to represent ‘a high, broad threshold’, which presents no uniform image for every individual participant. Some participants imagined a very high threshold while others thought it was very low and wide. This has influenced the results for the parameter step height and altered the results. This could explain the large standard deviations in Figure 1. Although motor imagery abilities were assessed in our study, they were not yet included to investigate how this imagery techniques were related to the attention capacity and the use of instructions. Adding this information may yield further insights into the role of imagery ability and the source of inter-individual differences.

The results of our study revealed that there is a difference in step height between the ST to DT, with participants taking higher steps during the DT, potentially interpreted as an order effect. It is plausible that asking participants to perform a Letter Fluency Task (DT) during walking exercises with different types of instructions was too difficult. During testing, we observed that participants sometimes stopped doing the DT and only focused on the walking instructions. So, because participants always got the ST condition first this might explain why step height was higher while performing the DT. When participants stopped doing the Letter Fluency Task (DT) all the attention was allocated to the walking instruction they already had worked with before. As a result, they may have improved their performance.

Previous research to implicit learning strategies were mostly case studies or had a very small sample size (Lajoie et al., 1996; Kleynen et al., 2013). Working with a small sample size does not give a robust representation of the population. Moreover, with a small sample size, the chances of significant results improve (Field, 2011). So, this suggests that more research is needed involving a larger group of participants.

A very big limitation of our study was also the small sample size. In the scatterplot of the CDT and dual task cost (Figure 3) it is shown that very small group of participants had a high score on the CDT (so a low attention capacity) and a high step height. In a small sample size like in the current study, a very small group within the sample size with deviating scores can influence the mean scores (Field, 2011).

Another limitation of our study was that we had no clear index of a good performance for gait and the parameter step height. Participants were asked to step over a high wide threshold and we assumed that higher steps are a better performance. But if participants imagined a low or average threshold, their step height would be lower; this does not mean that they did not perform well. It is simply impossible for us to establish what the participant imagined.

The last drawback is that during this study we lost data from the interactive walkway due technical deficits. For unknown reasons, not all Kinect cameras were transferring data. This result from this was that from five participants the data were not included.

The results of our study, and the interviews with the physiotherapists imply that it is beneficial to look at the attention capacities in older adults for movement instruction, but the predicted advantage of metaphoric instructions is currently not supported. The relationship between attentional capacity and metaphoric instructions implies that metaphoric instructions may not be more suitable for people with low attention function.

Future studies are needed to investigate the influence of using metaphoric instructions on objective gait measures and DT for further recommendations in the clinical rehabilitation setting.

Literature

Agner, A., Bernet, J., Brulhart, Y., Radlinger, L., & Rogan, S. (2015). Spatiotemporal gait parameters during dual task walking in need of care elderly and young adults. *Gerontology and Geriatry*, *48*(*8*), 1–6. http://doi.org/10.1007/s00391-015-0884-1

Baddeley, A., & Wilson, B. A. (1994). When implicit learning fails: Amensia and the problem of error elimination. *Neuropsychologia, 32*(*1*), 53-68.

Ballesteros, S., Kraft, E., Santana, S., & Tziraki, C. (2015). Maintaining Older Brain Functionality: A Targeted Review. *Neuroscience and Biobehavioral Reviews*, *55*, 453–477. http://doi.org/10.1016/j.neubiorev.2015.06.008

Braver, T. S., & Barch, D. M. (2002). A theory of cognitive control, aging cognition, and neuromodulation. *Neuroscience and Biobehavioral Reviews*, *26*(*7*), 809–817. http://doi.org/10.1016/S0149-7634(02)00067-2

Cahn-Weiner, D., Malloy, P. F., Boyle, P. A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist*, *14*(*2*), 187–195. http://doi.org/10.1076/1385-4046(200005)14

Caljouw, S. R., Veldkamp, R., & Lamoth, C. J. C. (2016). Implicit and explicit learning of a sequential postural weight-shifting task in young and older adults. *Frontiers in Psychology*, *7(9)*, 733. http://doi.org/10.3389/fpsyg.2016.00733

Callens, M., Tops, W., & Brysbaert, M. (2012). Cognitive profile of students Who enter higher education with an indication of dyslexia. *Plos one*, *7*(*6*). http://doi.org/10.1371/journal.pone.0038081

Field, A., (2011). *Discovering Statistics Using IBM SPSS Statistic.* London, Sage Publications Ltd.

Folstein, M. F., Folstein, S. E., & McHugh, P. (1975) 'Mini-mental state'. A practical method for grading the cognitive state of patients for the clinician. *Journal of psychiatric research*, *12*, 189-198.

Frensch, P.A., Wenke, D., & Rünger, D. (1999). A secondary tone-counting task suppresses expression of knowledge in the serial reaction task. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *25*, 260–274.

Ganzach, Y. (2016). Another look at the Spearman's hypothesis and relationship between Digit Span and General Mental Ability. *Learning and Individual*

Differences, *45*, 128–132. http://doi.org/10.1016/j.lindif.2015.12.026

Geerse, D. J., Coolen, B. H., & Roerdink, M. (2015). Kinematic validation of a multi-Kinect v2 instrumented 10-meter walkway for quantitative gait assessments. *Plos one*, *10*(10), 1–15. http://doi.org/10.1371/journal.pone.0139913

Hall, C. D., Echt, K. V, Wolf, S. L., & Rogers, W. a. (2011). Cognitive and motor mechanisms underlying older adults' ability to divide attention while walking. *Physical Therapy*, *91*(7), 1039–50. http://doi.org/10.2522/ptj.20100114

Holtzer, R., Wang, C., & Verghese, J. (2012). The relationship between attention and gait in aging: facts and fallacies. *Motor Control*, *16*(*1*), 64–80. http://doi.org/10.1016/j.biotechadv.2011.08.021.Secreted

Huxhold, O., Li, S. C., Schmiedek, F., & Lindenberger, U. (2006). Dual-tasking postural control: Aging and the effects of cognitive demand in conjunction with focus of attention. *Brain Research Bulletin*, *69*(*3*), 294–305. http://doi.org/10.1016/j.brainresbull.2006.01.002

Johnson, L., Burridge, J. H., & Demain, S. H. (2013). Internal and external focus of attention during gait re-education. *Journal of the physical therapy association and physical therapy*, *93*(*7*), 957-966.

Jiménez, L., & Méndez, C. (1999). Which attention is needed for implicit sequence learning? *Journal of Experimental Psychology: Learning, Memory and Cognition*, *25*, 236–259.

Kim, J. W., Lee, S. K., & Yoon, J. H. (2015). The distinctive effect of providing syllables in letter fluency testing: Literate vs. illiterate elderly persons. *Speech Communication*, *70*, 42–48. http://doi.org/10.1016/j.specom.2015.03.003

Kleynen, M., Wilson, M. R., Jie, L., Hekkert, L., Goodwin, V. A., & Braun, S. M. (2013). Exploring the utility of analogies in motor learning after stroke : a feasibility study. *International journal of rehabilitation research, 37(3)* 277-280. http://doi.org/10.1097/MRR.0000000000000058

Lajoie, Y., Teasdale, N., Bard, C., & Fleury, M. (1996). Upright Standing and Gait: Are There Changes in Attentional Requirements Related to Normal Aging? *Experimental Aging Research*, *22*(*2*), 185–198. http://doi.org/10.1080/03610739608254006

Liao, C. M., & Masters, R. S. (2001). Analogy learning: a means to implicit motor learning. *Journal of Sports Sciences*, *19*(5), 307–319. http://doi.org/10.1080/02640410152006081

Ling, F. C. M., Maxwell, J., Masters, R. S. W., McManus, A. M., & Polman, R. C. J. (2015). Psychometric properties of the movement-specific reinvestment scale for Chinese children. *International Journal of Sport and Exercise Psychology*, *3*, 1–13. http://doi.org/10.1080/1612197X.2015.1016087

Lord, S., & Rochester, L. (2007). Walking in the real world: concepts related to functional gait. *NZ Journal of Physiotherapy New Zealand Journal of Physiotherapy*, *35*(353), 126–130.

Maxwell, J. P., Masters, R. S., & Eves, F. F. (2000). From novice to no know-how: a longitudinal study of implicit motor learning. *Journal of Sports Sciences*, *18*, 111–120. http://doi.org/10.1080/026404100365180

Maxwell, J. P., Masters, R. S. W., Kerr, E., Weedon, E., Masters, R. S. W., Kerr, E., & The, E. W. (2001). The implicit benefit of learning without errors. *The quartely journal of experimental psychology*, *54(4),*1049-1068. http://doi.org/10.1080/713756014

Rubenstein, L. Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Ageing*, *35*, 37–41. http://doi.org/10.1093/ageing/afl084

Sánchez-Cubillo, I., Periáñez, J. a, Adrover-Roig, D., Rodríguez-Sánchez, J. M., Ríos-Lago, M., Tirapu, J., & Barceló, F. (2009). Construct validity of the Trail Making Test: role of task-switching, working memory, inhibition/interference control, and visuomotor abilities. *Journal of the International Neuropsychological Society : JINS*, *15*(3), 438–450. http://doi.org/10.1017/S1355617709090626

Swanson, H. L., & Beebe-Frankenberger, M. (2004). The Relationship Between Working Memory and Mathematical Problem Solving in Children at Risk and Not at Risk for Serious Math Difficulties. *Journal of Educational Psychology*, *96*(*3*), 471–491. http://doi.org/10.1037/0022-0663.96.3.471

Verhaeghen, P., & Cerella, J. (2002). Aging, executive control, and attention: A review of meta-analyses. *Neuroscience and Biobehavioral Reviews*, *26*(*7*), 849–857. http://doi.org/10.1016/S0149-7634(02)00071-4

Volkers, K., & Scherder, E. (2014). Physical performance is associated with working memory in older people with mild to severe cognitive impairment. *BioMed Research International*, *2014*, 18–20.

Williams, J., Pearce, A. J., Loporto, M., Morris, T., & Holmes, P. S. (2012). The relationship between corticospinal excitability during motor imagery and motor imagery ability. *Behavioural Brain Research*, *226*(*2*), 369–375. http://doi.org/10.1016/j.bbr.2011.09.014

Wilson, B. A., Baddeley, A., Evans, J., & Shiel, A. (1994). Errorless learning in the rehabilitation of memory impaired people. *Neuropsychological Rehabilitation*, *4*(*3*), 307–326. http://doi.org/10.1080/09602019408401463

Wulf, G., & Shea, C. H. (2002). Principles derived from the study of simple skills do not generalize to complex skill learning. *Psychonomic Bulletin & Review*, *9*(*2*), 185–211. http://doi.org/10.3758/BF03196276

Yogev, G., Giladi, N., Peretz, C., Springer, S., Simon, E. S., & Hausdorff, J. M. (2005). Dual tasking, gait rhythmicity, and Parkinson's disease: Which aspects of gait are attention demanding? *European Journal of Neuroscience*, *22*(*5*), 1248–1256. http://doi.org/10.1111/j.1460-9568.2005.04298.x