Implications of dual-tasking on dementia research

July 6 2015, by Ríona Mc Ardle

A group of friends chat as they walk in St. Marlo, France. Credit: Antoine K (Flickr)

You turn the street corner and bump into an old friend. After the initial greetings and exclamations of "It's so good to see you!" and "Has it been that long?", your friend inquires as to where you are going. You wave your hands to indicate the direction of your desired location, and with a jaunty grin, your friend announces that they too are headed that way. And so, you both set off, exchanging news of significant others and perceived job performance, with the sound of your excited voices trailing behind you.

This scenario seems relatively normal, and indeed it occurs to hundreds of people in everyday life. But have you ever truly marvelled our ability to walk and talk at the same time? Most people discount gait as an automatic function. They spare no thought to the higher cognitive processes that we engage in, in order to place one foot in front of the next. The act of walking requires huge attentional and executive function resources, and it is through the sheer amount of practice we accumulate throughout our lives that makes it feel like such a mindless activity. Talking while walking recruits even more resources with the additional requirement of an attentional split – this is so we don't overemphasize our attention on one task at the detriment of the other. And it's not just talking! We can assume all manner of activities while walking – carrying trays, waving our hands, checking ourselves out in the nearest shop window. But what sort of costs does such multitasking afford us?

Dual-Tasking: How well can we really walk and talk?

Dual-tasking refers to the simultaneous execution of two tasks – usually a walking task and a secondary cognitive or motor task. It is commonly

used to assess the relationship between attention and gait. Although there is no consensus yet on the manner in which dual-tasking may hinder gait, dual-task studies have demonstrated decreased walking speed and poorer performance of the secondary task. This has been particularly seen in healthy older adults, who struggle more with the secondary task when prioritizing walking – this is likely to maintain balance and avoid falls. Such findings have supported the role of executive function and attention in gait, as both are implicated as part of frontal lobe function. Age-related changes in the brain have demonstrated a focal atrophy of the frontal cortex, with reductions of 10-17% observed in the over-65 age group. When compared to the reported 1% atrophy of the other lobes, it can be postulated that the changes to the frontal lobes contribute to gait disturbances experienced by the elderly. The older generation must recruit many of the remaining attentional resources in order to maintain gait, and thus have few left to carry out other activities at the same time.

It has been incredibly difficult to confirm the frontal cortex's role in gait from a neurological perspective. Imaging techniques have largely been found unsatisfactory for such an endeavor, as many rely on an unmoving subject lying in a fixed position. However, a recent study in PLOS ONE has shed some light in the area. Lu and colleagues (2015) employed Functional Near-Infrared Spectroscopy (fNIRS) to capture activation in the brain's frontal regions: specifically, the prefrontal cortex (PFC), the premotor cortex (PMC) and the supplementary motor areas (SMA). Although obtaining a similar image of the cortex to that of functional magnetic resonance imaging (fMRI), fNIRS can acquire these during motion. These researchers laid out three investigatory aims:

1. To assess if declining gait performance was due to different forms of dual task interference.
2. To observe if there was any differences in cortical activation in

the PFC, PMC and SMA during dual-task and normal walking.
3. To evaluate the relationship between such activation and gait performance during dual-tasking.

The research team predicted that the PFC, PMC and SMA would be more active during dual-task due to the increased cognitive or motor demand on resources.

Lu and colleagues recruited 17 healthy, young individuals to take part in the study. Each subject underwent the three conditions three times each, with a resting condition in between. The conditions were as follows: a normal walking condition (NW) in which the participant would be instructed to walk at their usual pace, a walking while carrying out a cognitive task condition (WCT) in which the subject had to engage in a subtraction task, and a walking while carrying out a motor task condition (WMT) in which the participant had to carry a bottle of water on a tray without spilling it. Results showed that both the WCT and WMT induced a slower walk than the NW. Interestingly, WMT displayed a higher number of steps per minute and a shorter stride time – this could be attributed to the intentional alteration of gait in order not to spill the water. An analysis of the fNIRS data revealed that all three frontal regions were activated during dual-task conditions. The PFC showed the strongest, most continuous activation during WCT. As the PFC is highly implicated in attention and executive function, its increased role in the cognitive dual-task condition seems reasonable. The SMA and PMC were found to be most strongly activated during the early stages of the WMT. Again, this finding makes sense as both these areas are associated with the planning and initiation of movement – in this case, the researchers postulated that this activity may reflect a demand for stability of the body in order to carry out the motor task. This study has successfully demonstrated the frontal cortex's role in maintaining gait, particularly when concerned with a secondary task.

Why is this important?

Although gait disturbances are extremely rare in young people, their prevalence increases with age. 30% of adults over 65 fall at least once a year, with the incidence rate climbing to 50% in the over-85 population. Falls carry a high risk of critical injuries in the elderly, and often occur during walking. This latest study has provided evidence for the pivotal roles of executive function and attention in maintaining gait, and has allowed us to gain insight into the utilities of dual-task studies. Having correlated activation of the frontal cortex with carrying out a secondary task while walking, poor performance of one of these tasks may reveal a subtle deficit in attention or executive function. Therefore, gait abnormalities may be able to act as a predictor of mild cognitive impairment (MCI) and even dementia. Studies have reported that a slowing of gait may occur up to 12 years prior to the onset of MCI, with longitudinal investigations observing that gait irregularities significantly increased individuals' likelihood of developing dementia 6-10 years later.

But what does the relationship between gait and cognition tell us about dementia? Dementia is one of the most prevalent diseases to afflict the human population, with 8% of over-65s and over 35% of the over-85s suffering from it. It is incredibly important for researchers to strive to reduce the amount of time individuals must live their lives under the grip of such a crippling disorder. Our growing knowledge of gait and cognition can allow us to do so in two different ways: through early diagnosis of dementia and through developments in interventions.

For the former, a drive in research has begun regarding the correlation of different gait deficits with dementia subtypes. The principle behind this is that the physical manifestation of the gait disturbance could lend clinicians a clue as to the lesion site in the brain – for example, if a patient is asked to prioritize an executive function task when walking,

and displays a significant gait impairment while doing so, this may predict vascular dementia. This is because executive function relies on frontal networks, which are highly susceptible to vascular risk. Studies have shown that this type of dual-task will often cause a decrease in velocity and stride length and are associated with white matter disorders and stroke. To the latter point, practice of either gait or cognition may benefit the other. It has been acknowledged that individuals who go for walks daily have a significantly reduced risk of dementia. This is attributed to gait's engagement of executive function and attention, which exercises the neural networks associated with them. Similarly, improving cognitive function may in turn help one to maintain a normal gait. Verghese and colleagues (2010) demonstrated this in a promising study, in which cognitive remediation improved older sedentary individuals' mobility.

Closing thoughts

As both a neuroscientist and a citizen of the world, one of my personal primary concerns is the welfare of the older generation. The aging population is growing significantly as life expectancy increases and these individuals are susceptible to a range of medical issues. While any health problem is hard to see in our loved ones, dementia and failing cognition are a particularly difficult brunt on both the individual, their family and society as a whole. Our exploration into the relationship between gait and cognition has so far offered a glimmer of hope into progressing our understanding and fight against dementia, and I personally hope this intriguing area continues to do just that.

More information: Beurskens, R., & Bock, O. (2012). "Age-related deficits of dual-task walking: a review." *Neural plasticity*, 2012.

Holtzer, R., Mahoney, J. R., Izzetoglu, M., Izzetoglu, K., Onaral, B., & Verghese, J. (2011). "fNIRS study of walking and walking while talking

in young and old individuals." The *Journals of Gerontology* Series A: Biological Sciences and Medical Sciences, glr068.

Li, K. Z., Lindenberger, U., Freund, A. M., & Baltes, P. B. (2001). "Walking while memorizing: age-related differences in compensatory behavior."*Psychological Science*, 12(3), 230-237.

Lu, C. F., Liu, Y. C., Yang, Y. R., Wu, Y. T., & Wang, R. Y. (2015). "Maintaining Gait Performance by Cortical Activation during Dual-Task Interference: A Functional Near-Infrared Spectroscopy Study." *PloS one*, 10(6), e0129390.

Montero-Odasso, M., & Hachinski, V. (2014). "Preludes to brain failure: executive dysfunction and gait disturbances." *Neurological Sciences*, 35(4), 601-604.

Montero-Odasso, M., Verghese, J., Beauchet, O., & Hausdorff, J. M. (2012). "Gait and cognition: a complementary approach to understanding brain function and the risk of falling." *Journal of the American Geriatrics Society*,60(11), 2127-2136.

Sparrow, W. A., Bradshaw, E. J., Lamoureux, E., & Tirosh, O. (2002). "Ageing effects on the attention demands of walking." *Human Movement Science*, 21(5), 961-972.

Verghese, J., Mahoney, J., Ambrose, A. F., Wang, C., & Holtzer, R. (2010). "Effect of cognitive remediation on gait in sedentary seniors." The *Journals of Gerontology* Series A: Biological Sciences and Medical Sciences, 65(12), 1338-1343.

Yogev-Seligmann, G., Hausdorff, J. M., & Giladi, N. (2008). "The role of executive function and attention in gait." *Movement Disorders*, 23(3), 329-342.