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Proactive control to navigate our daily environments

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ABBREVIATIONS

ALAs	Anticipatory Locomotor Adjustments

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ABSTRACT
Safely navigating our environment is crucial to daily living, but the study of locomotor navigational control in relation to the complex interaction of personal and environmental factors is still in its infancy. Work to now has proposed different proactive control variables for collision avoidance based on visual information. Such control has more recently been shown to be specific to personal (e.g., age, neurological diseases) and environmental (e.g., obstacle type) characteristics. Continued study of the complex person-environment interaction is required along with continued theorization on combined proactive and reactive control factors.

KEYWORDS: Locomotion | Navigation | Vision | Anticipatory Control | Obstacle Avoidance | Cluttered Environment

The interest in understanding how humans walk dates back centuries while more formal measurements using technology arrived later in the 19th century. The 20th century saw an exponential growth in locomotor studies, especially with the advancement in kinetic and motion capture technology, and from the latter part of that century to now, the advent of virtual reality has provided ways to control environmental factors. In all this, the study of how locomotion is adapted to the environment is fairly recent despite the fact that navigating and adapting for the environment makes up a large part of our daily locomotor activity. Locomotor navigation is performed best when the physical characteristics of the environment can be anticipated. Such Anticipatory Locomotor Adjustments (ALAs) rely vitally on visual information to both accommodate environmental facilitators (e.g., passing through a door aperture) and avoid environmental obstacles (e.g., circumventing objects or another pedestrian).

To accommodate an aperture crossing requires accurate visuo-motor coupling. Such crossing behaviours are dependent on the physical characteristics of the aperture (i.e., static, closing, people, poles, etc.) and are scaled either to one's body size or action capabilities. For instance, people use body scaled information when passing through static apertures, and apertures smaller than about 1.3 times one's shoulder width become a critical point to elicit shoulder rotation [1]. Conversely, when apertures are dynamically changing size, individuals tend to adjust their walking speed when they are approximately 2 m from the aperture, although this distance can decrease when the individual's knowledge of their action capabilities is affected (e.g., fatigue) [2].

Such proactive control for locomotor navigation is also crucial for circumventing objects. Circumvention involves first an ‘en bloc’ control of head and trunk rotation thought to preserve visual attention on the obstruction [3]. This then initiates a two-phase trajectory deviation beginning about 4.5m from the obstacle with a more a pronounced deviation within 2m that allows the preservation of an elliptical safety zone, or personal space, around the object [4]. Like for aperture crossing noted above, these control variables that define ALAs for single object circumvention are also adapted for different contexts related to personal and environmental factors.

Yet, daily environmental contexts can involve more complex navigational situations such as walking through crowds. Work involving crowd simulation [5] can be used to understand if pedestrians use multiple strategies to navigate in a densely populated environment that includes both path planning and local collision avoidance. Analysis of pedestrians’ trajectories and gaze behaviour in crowds has shown that virtual pedestrians with a perceived risk of collision are fixated 2.3 times more [6]. Within a crowd context, local collision avoidance control needs to regulate a proxemics that both seeks apertures and maintains social distancing, depending on the crowd properties (e.g., density, geometry). The relative weighting between path planning and obstacle avoidance could be a dynamic process which evolves depending on the environmental context.

The navigation tasks noted above are affected by changes in one’s sensorimotor and cognitive capacities whether due to normal ageing or to more important changes from impairments. For example, when circumventing obstacles mimicking diagonally approaching pedestrians, people with stroke presented with approximately 25% larger obstacle clearances and those with more functional limitations preferentially passed behind as opposed to in front of the obstacles [7]. These alterations in collision avoidance strategies and the ensuing number of collisions with surrounding obstacles or pedestrians become even more pronounced in the presence of visual-perceptual disorders such as post-stroke hemineglect as well as with the addition of a simultaneous cognitive task while walking (e.g., dual tasking) [8]. Similarly, it has also been shown that people with Parkinson’s Disease delay their gaze fixations towards an obstacle to be circumvented by about 1s as compared to neurologically healthy individuals, and this delay is increased when dual-tasking (about 2s). This population also move their head 17.5% more than their trunk while preparing for obstacle circumvention [9]. These are only brief examples of impaired locomotor navigation ability. More research involving populations from mild to severe impairments in cognitive and physical functioning is required in order to transfer evidence and better intervene on daily mobility and social participation. The natural combination of cognitive, social, and motor demands of locomotor navigation can be exploited to assess mobility within more ecological contexts at various stages following impairments.

Overall, much more research is needed to better understand the complex human-environment interaction underlying locomotor navigation. While it is of our opinion that the control of ALAs is planned and predominantly proactive in nature, there is other research suggesting that locomotor navigation is controlled more on-line [10]. Further modeling and experimental studies exploring the trade-off between reactive and anticipatory factors are needed to not only advance knowledge of locomotor navigation control but to continue to develop more effective assessment and training tools for improving mobility in different populations.

REFERENCES

1. Hackney AL, Cinelli ME. Older adults are guided by their dynamic perceptions during aperture crossing. *Gait Posture*. 2013;37(1):93-7. doi: 10.1016/j.gaitpost.2012.06.020
2. Snyder NA, Cinelli ME. Aperture crossing in virtual reality: Physical fatigue affects response time not decision-making. *J Mot Behav*. 2021;54(4):429-437. doi: 10.1080/00222895.2021.2006595
3. Vallis L, McFadyen, BJ. Locomotor adjustments for circumvention of an obstacle in the travel path. *Exp Brain Res*. 2003;152:409-414. doi: 10.1007/s00221-003-1558-6
4. Gérin-Lajoie M, Richards CL, McFadyen BJ. The Negotiation of Stationary and Moving Obstructions during Walking: Anticipatory Locomotor Adaptations and Preservation of Personal Space. *Motor Control*. 2005;9:242-269. doi: 10.1123/mcj.9.3.242
5. van Toll W, Pettré J. Synchronizing navigation algorithms for crowd simulation via topological strategies. *Comput Graph*. 2020;89:24-37. doi.org/10.1016/j.cag.2020.04.003
6. Meerhoff LA, Bruneau J, Vu A, Olivier A-H, Pettré J. Guided by gaze: Prioritization strategy when navigating through a virtual crowd can be assessed through gaze activity. *Acta Psychol*. 2018;190:248-257. doi: 10.1016/j.actpsy.2018.07.009
7. Darekar A, Lamontagne A, Fung J. Locomotor circumvention strategies are altered by stroke: I. Obstacle clearance. *J Neuroeng Rehabil*. 2017;14(1):56. doi: 10.1186/s12984-017-0265-7
8. Aravind G, Lamontagne A. Dual tasking negatively impacts obstacle avoidance abilities in post-stroke individuals with visuospatial neglect: Task complexity matters! *Restor Neurol Neurosci*. 2017;35(4):423-436. doi: 10.3233/RNN-160709
9. Pereira VAI, Polastri PF, Simieli L, Rietdyk S, Itikawa Imaizumi LF, Moretto GF, Penedo T, Rodrigues ST, Barbieri FA. Parkinson's patients delay fixations when circumventing an obstacle and performing a dual cognitive task. *Gait Posture*. 2019;73:291-298. DOI: 10.1016/j.gaitpost.2019.07.37
10. Fajen BR, Warren WH. Behavioral dynamics of steering, obstacle avoidance, and route selection. *J Exp Psychol Hum Percept Perform*. 2003;29(2):343-62. doi: 10.1037/0096-1523.29.2.343

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